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By

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PERCEPTUAL CONDITIONS OF ASSOCIATION[1,2]

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THIS is an investigation of the role of the perceptual characteristics of the stimulus in the formation of associations.

It would be natural to suppose that the dependence of association upon the properties of the stimulus constitutes a central problem, given that what is associated corresponds, often quite faithfully, to what has been perceived. For reasons that reach far into the history of thinking in our field, this has not been the case; the nature of the stimulus has largely been taken for granted. Nowhere is this more evident than in the traditional theories and experimental studies of association. Investigation carefully controls such conditions as contiguity, frequency, temporal relations, or the circumstances surrounding the appearance of the stimulus. But the properties of the stimulus itself are as a rule not systematically treated; indeed, often they are described merely by naming or pointing. We propose to show that when one takes the structure of the stimulus into account, new and neglected questions arise concerning the relation of perception to association and concerning the nature of association.

Since we rely for evidence concerning the formation of associations on the data of recall, we shall begin with the latter. Recall is the end product of a sequence of events. The distal stimulus, the proximal stimulus, the resulting perceptual process, the aftereffects it produces, and their subsequent reactivation in the form of recall, are a series of consecutive events each of which depends directly on those preceding. Many of the formulations concerning associations are statements of relation between the data of recall and these earlier events. Ideally, each of the successive steps just mentioned should find a place in the study of associations. Practice falls far short of this procedure. Before introducing the problem of this investigation, it will be helpful to see how we generally go about establishing a relation between recall and its conditions.

For illustration we choose the kind of recall termed associative. The basic observation is that the experience of *a* is followed by the recall of *b*. We consider this an instance of recall because we relate it to an earlier occasion when the corresponding stimuli, A and B, were given and observed. The correspondence between what is recalled and what was originally experienced forces us to conclude that the latter produced an aftereffect that persists and can be reactivated. It is on this ground that we distinguish between the formation and recall of associations. Further, we bring into relation the data of recall to the particular conditions prevailing at the time of original experience. Thus, if A and B were spatially contiguous, we relate the obtained recall to the condition of contiguity; similarly, if A and B appeared in a particular temporal succession, or with a given frequency.

In the instance just cited, it is usual to refer interchangeably to the preceding distal, proximal, and perceptual conditions. This ambiguity is harmless when, as is often the case, the correspondence between these respective events is so lawful as to pose no

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[2] For their helpfulness in making available the facilities of their Departments in the conduct of some of the experiments here reported, the writer wishes to express his gratitude to John L. Kennedy of Princeton University, Francis W. Irwin of the University of Pennsylvania, M. E. Bitterman of Bryn Mawr College, George V. Coelho and Douglas H. Heath of Haverford College, and Nelson G. Hanawalt of Rutgers University.

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problem of distinction. As a rule, when A and B are contiguous, the proximal stimuli are also contiguous, and so are the phenomenal *a* and *b*. But the structural description of the stimuli is often equally informal. This practice slights the advantages inherent in an exact specification of the stimulus, advantages that are particularly important when the stimulus is perceptual.

The Problem

When we speak of the formation of an association we refer, then, to a functional connection between two experienced contents, an *a* and a *b*, corresponding to the objectively given A and B. That an association presupposes *two* terms is so obvious a requirement that it has not provoked further inquiry. We shall nevertheless see that this necessary but unexamined condition conceals ambiguities and problems of consequence about the role of perception in association.

An examination of the classical association experiment as a perceptual situation will serve to introduce the present problem. The standard procedure is to introduce the learner to a pair of stimuli, A and B, pairedness being established by means of distinctive contiguity—spatial, temporal, or spatiotemporal. Further, the stimuli are as a rule discrete and heterogeneous.

The latter property of the association experiment brings us to a surprising observation. Investigation in this region has been exclusively concerned with a particular kind of relation, namely, with stimuli each of which is *a distinct perceptual or cognitive unit.* Indeed, this property has become the criterion for the identification of an association. Investigation has confined itself to associations formed between one unit and another. The outstanding feature of this relation is that the units are (or approximate to) a mere assemblage. Each has a separate existence; take one away and little happens to the other.

This practice singles out a stimulus relation that is, to be sure, frequent in experience and important for theory. But it is neither the sole nor perhaps the representative case. There are other stimulus relations that are equally relevant to the problems in this region. Most challenging are those instances in which the respective terms belong to the same well-structured unit. Relations of the latter kind have not been investigated in connection with the problems of association, probably because the special character of the prevailing procedure was not suspected. At the same time, it seems justified to say that the various associative interpretations were intended to apply to most other instances of functional connection.

The thought from which we start may be restated as follows. The objective relations between an A and B may be of different kinds; the corresponding perceived relations may be decisive for the functional intimacy between the terms in question (and therefore for retention and recall). At the one extreme, an *a* may be so completely absorbed in a larger unit *b* that it loses psychological identity. This is the case that Gottschaldt (1926) has investigated in the region of perception; one can then no longer speak of association. At the other extreme, *a* and *b* may be discrete units; this is the case that investigation has favored under the rubric of association. There are also intermediate cases, with some of which we will be concerned, in which *a* and *b* belong to a single, tightly organized unit while retaining their respective identities.

The last-mentioned relation raises the following question. Most units consist of parts; more generally, they possess more than one property, and more than one aspect. The recall of such a unit involves the recall of its several parts or properties, as well as their order. The question of the functional intimacy between the parts of a unit is surely as pertinent as that between distinct units. There are, in short, operations necessary to the perception and recall of a unit that are formally analogous to the perception and recall of heterogeneous unit pairs.

In the light of this distinction, we ask the following questions. Are there observable differences between the association of heterogeneous perceptual units and the functional connections formed within a clearly

structured perceptual unit? There is also a more fundamental question: whether the respective functional connections are qualitatively the same, or whether they involve a difference of process.

In the investigation that follows we have studied the functional connections established between stimuli related in a number of different ways. Our particular aim has been to compare the functional intimacy between heterogeneous units and between the interdependent parts of clearly structured units. The rationale of the experimental procedures follows directly from the problems just stated. We have studied the similarities and differences between stimulus conditions exemplifying different relations, but as far as possible identical in content. We have attempted in each case to specify independently the objective and the phenomenal properties of the stimulus. Since there are different particular sources of unity and nonunity, a range of conditions was studied.

The Constitutive Relation

For the first step of this investigation we chose perceptual stimuli bound by the relation we will call *constitutive*. For this purpose we turned to the following perceptual datum. A visual contour possesses at minimum two properties: it delineates a shape, but it also has a concrete material character; the contour line may be thick or thin, continuous or discontinuous, dashed or dotted. The same form, such as the circle in Figure 1 below, may thus be represented in different ways. Let us call the one property of a contour line its *form* (or F), the other its *mode* (or M).

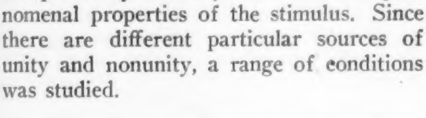

Fig. 1. Form and mode.

Concerning these properties of a visual contour we may say the following. *First*, form and mode are inseparable: a given form must appear in one or another mode. But *second*, they are not invariably united: a given form may appear in a number of modes. *Third*, the mode of a contour also has form quality: it is a form in its own right. *Fourth*, the modal form in turn may possess a mode. *Fifth*, the final modal property of a visual stimulus has a mode which is continuous. The dot and the straight line are instances of ultimate modes.

The relation between form and mode may be characterized as follows. 1. Each is a perceptual unit, the mode as much as the form, but they stand in a particular hierarchical relation. The spatial distribution of the modes generates a particular shape; thus, the shape is dependent on the modes as its constituents. The relation of dependence is such that neither term can retain its character without the other. 2. As a necessary corollary, form and modes are identical in locus; the form is where the modes are. 3. The modes generate a shape by virtue of their position, not through their particular form character. Or, they delineate a shape in terms of their point quality alone. It follows that the relation of the modal form to the encompassing form is not identical with the category of part—whole relation. 4. Finally, form and mode are clearly discriminable.

Concerning stimuli of this structure one can ask: how strongly connected do the aspects here singled out become under given conditions? When a subject (*S*) has inspected one of the figures above and attempts later to recall it, we can establish whether he has recalled one, or both, or neither of the contour properties. In short, we can determine the coherence or *jointness* of the given properties in recall, or their functional intimacy.[4] If, now, we could separate these properties and constitute them into distinct units, we would have succeeded in establishing a parallel condition, conforming to the traditional associative paradigm, to be compared with the preceding. This we propose to do in the following manner.

[4] The stimuli in question possess, to be sure, other properties as well—such as size, orientation, position in space—but we do not consider them in this investigation.

Procedure

The Stimulus Conditions

The stimuli selected for the first experiments are reproduced in Figure 2. Those at the left consist of different forms whose contours also differ in mode. At the right the same forms are all drawn continuously, but each is paired with a line containing the modal components of the corresponding figure at the left.

The difference between the two sets of stimuli may be described in terms of the relations they exhibit. In the first set, the relation of mode and form is constitutive. The second set of stimuli consists of the same contents, but these are now spatially separated. Separation in this case destroys the constitutive relation and abolishes the structural interdependence of the contents. These now form a pair of heterogeneous items, within which each has the same role or rank. It should be noted that form and mode were chosen to be heterogeneous, and that they were equally heterogeneous in the two series.

We can also characterize the two series in terms of their unity. By virtue of the constitutive relation, form and mode of the first series belong to the same unit; the corresponding contents of the second series are dual. The basis for this distinction is phenomenal; observers will agree that the two series differ in unity. Accordingly, we will call the first stimulus set unitary (or U) and the second set nonunitary (or non-U). This designation is intended at this point to be only descriptive.

It may be helpful to state in what respects these stimulus conditions do not differ. (*a*) Since form and mode are heterogeneous, and equally so in both conditions, the terms "unitary" and "nonunitary" refer not to the number of stimulus properties, but to the perceived relations between them. With respect to content, both sets of conditions were equally dual. (*b*) It follows that numerical singleness and duality were not the essential differences. A nonunitary pair was such not because it consisted of separated units, but rather because the units were heterogeneous. Distinct units can well function as parts of an encompassing unit; again the relation is decisive.

The U series consisted of 10 stimuli, the non-U series of 10 pairs of stimuli. Thus, form and mode correspond to the A and B terms of the traditional association experiment.[5]

The forms and modes were selected so as to be relatively simple and easily reproducible. We attempted to avoid the combination of forms and modes that might be similar or demand each other for figural reasons. (For a check on this requirement see pp. 10–11.)

[5] Although the distinction between form and mode applies only to the unitary stimuli, we will, for the sake of convenience, designate similarly the corresponding parts of the nonunitary stimuli.

The stimuli were drawn in black pencil on a white card (4 in. × 6 in.). The figures occupied, in both conditions, the center of the left-hand side of the card. The line portions of the non-U stimuli were centered on the right-hand side of the card, and were 1¾ in. long. The distance between figure and line of the latter stimuli varied from 1½ to 2 in., depending on the shape of the former.

The contour line of a given U stimulus consisted of a sequence of identical modal forms. Six stimuli had discontinuous contours, four were drawn in continuous contour. The orientation of the modes

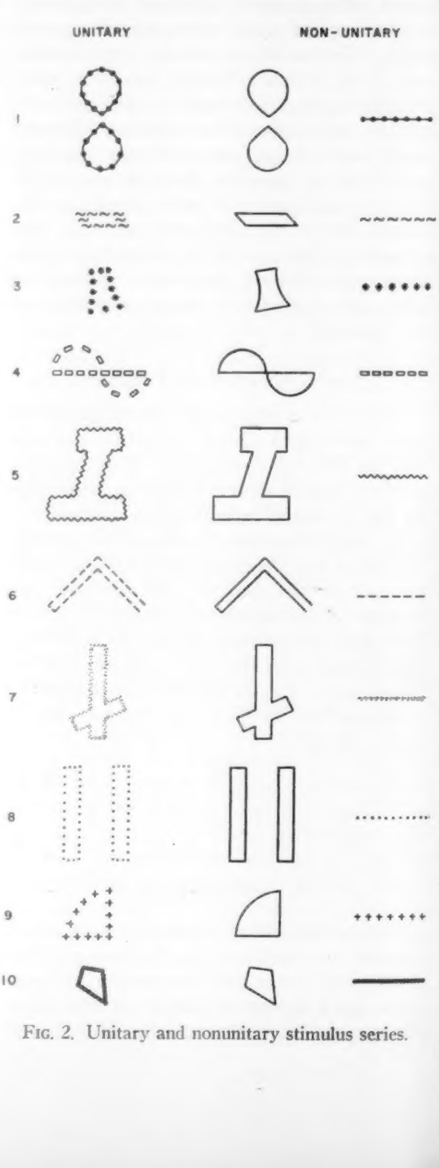

FIG. 2. Unitary and nonunitary stimulus series.

was kept constant, or independent of the changing orientation of the contour line, in all but two cases (stimuli 6 and 9).

The lines of the non-U stimuli were all drawn horizontally. This involved a change of orientation of the modes in the transition from the U to non-U series in three cases (stimuli 6, 8, and 9).

Conditions of Learning

Experimentation was done individually. The cards on which the stimuli appeared were placed in front of *S* against a slightly inclined wooden support stand. Each stimulus was shown singly for a period of 4 sec.; timing was done with a metronome. Each card was placed face down at the end of 4 sec., immediately exposing the next card. The stimuli were shown in the order in which they are numbered in Figure 2.

The conditions of learning were identical in each of the following variations. *S*s were instructed to inspect the figures with care so that they could later reproduce them exactly. All *S*s were thus directed to anticipate a free recall test. Particular care was taken to instruct *S*s in the non-U condition that they were to reproduce the *pairs* of stimuli on each card. It was also made clear to all *S*s that it was not necessary to recall the order in which the stimuli appeared.

The instructions were as follows:

Learning instructions: Unitary

This is a simple learning experiment. I am going to show you in succession a number of figures on the following cards.

After I have shown you the cards once, I will ask you to remember and draw the figures that you have seen. Look at each card carefully, so that you may be able to recall as many of the figures as possible. You will try to make your drawings look as much like the original as possible.

Each card will be shown once. Do not try to memorize the sequence in which the cards are shown. Any questions?

Learning instructions: Nonunitary

This is a simple learning experiment. I am going to show you in succession a number of cards.

Each card has two drawings on it—at the left is a figure, and at the right is a line drawn in a particular way.

After I have shown you the cards once, I will ask you to recall and draw the figure and the line that appeared on each card. Look at the drawings carefully so that you may be able to recall as many of the *pairs* as possible, and to draw them exactly as they appeared in the original. Please note that the task is to remember the *pairs* of drawings on each card. You will try to make your drawings look as much like the original as possible.

Each card will be shown once. Do not try to memorize the sequence in which the cards are shown. Any questions?

Conditions of Recall

Recall was tested 3 min. following the exposure of the last stimulus. The first 2 min. of this interval were occupied with a side task, consisting of the solution of anagrams. The *S*s were then interrupted and given the recall instructions.

There were three conditions of recall (with comparable groups), both in the unitary and nonunitary conditions.

Experiment 1: Free recall. *S*s were provided with blank booklets on which they reproduced all the stimuli they could recall. They were instructed to draw the contents of one stimulus card to a page, then to turn the page back, and were warned not to return to it subsequently. No strict time limit was imposed; the experiment came to an end when it became evident that *S* could make no further progress. The U *S*s were urged to reproduce either the form or mode alone when they could not recall a stimulus completely, and to guess when they were not certain. In the non-U condition they were asked to reproduce one of a pair when they could not recall its partner.

We reproduce below the recall instructions:

Free recall instructions: Unitary

Will you now draw, in this booklet, the figures exactly as they appeared earlier. Draw one figure to a page and then fold it under. You are free to recall the figures in any order.

You will have noticed that each figure was drawn with a different contour. If you remember only the figure, but not the form of the contour, just draw the figure in continuous outline. Similarly, if you remember only the form of the contour, but not the figure with which it went, draw a few samples of the contour. If you are not sure, try to guess.

Free recall instructions: Nonunitary

Will you now draw, in this booklet, the *pairs* of figures and lines exactly as they appeared earlier. Draw one pair to the page, and then fold it under. You are free to recall the pairs in any order.

If you remember one of the pairs only, draw it; if you are not sure of the other member of the pair, try to guess.

Experiment 2: Recall of mode. The booklets carried exact reproductions of the forms, all drawn continuously, one to a page. In the U condition the task was to draw the same figure with its original mode;[6] in the non-U condition the task was to reproduce the previously paired line. Except for

[6] *S*s were allowed to draw only a few samples of the mode when they showed impatience about going ahead.

the necessary changes the recall instructions were patterned after those reproduced above.

The order of the forms in the recall test was different from the presentation order, but constant for the entire group. Again, no exact time limit was imposed; as a rule *S*s did not stay unduly long with any stimulus. Once they passed it, they were not allowed to return or make corrections. We shall refer to this as the form-to-mode (F→M) test.

Experiment 3: Recall of form. The booklets carried (on successive pages) each of the modal characters drawn as a line. U *S*s were instructed to recall and draw the figure that originally appeared in that mode; non-U *S*s were to draw the figure that had been previously paired with the given modal line. The instructions paralleled those of Experiment 2. The order of the modes was identical with that of the forms in the recall test of Experiment 2. We will call this the mode-to-form (M→F) test.

Except where otherwise stated, the *S*s were Swarthmore College students. There was an equal number of men and women in each variation.

Scoring

We will first describe the procedure of scoring the free recall reproductions. Each reproduction was first scored independently for form (F) and mode (M). The method of scoring was liberal; a form or mode was scored correct if it was recognizable as one belonging to the series. Changes in orientation, size, or proportion of the forms, and similar changes of mode, were not taken into account. The reproductions were scored by two judges; in case of disagreement they reached a joint decision. The task of scoring was relatively simple; disagreements occurred infrequently. We may note that certain highly stable and reproducible results, to be described subsequently, demonstrate that the procedure of scoring, despite an irreducible subjectivity, was quite adequate to the present purpose.

In computing an *S*'s total recall score we proceeded as follows. Each correct reproduction of a form or of a mode received a score of 1. (Thus, the complete reproduction of a U stimulus received a score of 2.) If a form or mode was reproduced several times, it was scored as correct only once. If one of the reproductions was a correct pairing, it was recorded as correct at that point; if it was not correctly paired, it was scored as correct upon first recall.

We also scored independently for accuracy of *joint* recall of form and mode, a measure that provides an index of the intimacy of connection between them. Here, we call attention to a terminological point. The joint recall of *a* and *b* in the nonunitary condition has always been called associative. Since we must leave open whether joint recall in the unitary condition involves the same process, we will employ a more neutral designation and will speak of correct or incorrect pairing. This more general term is not intended to describe the process in question; it is rather descriptive of the procedure for scoring jointness of recall. It can, of course, also be applied without prejudice to the nonunitary condition.

The structure of the task permits the following systematic and exhaustive way of scoring and ordering the data. 1. Form and mode correctly reproduced and correctly paired. We designate these recalls as +(FM), the plus sign preceding the parenthesis denoting a correct pairing. For non-U stimuli this category describes the correct reproduction of a figure and its paired line. 2. Form and mode correctly reproduced but incorrectly paired. These were instances in which a form was joined to a mode that went with another form. We refer to these reproductions as −(FM), the minus sign preceding the parenthesis denoting incorrect pairing. 3. Form alone correctly reproduced. Here were included instances in which the mode was either omitted, or an extraserial mode was introduced. Also belonging to this category were instances of a repeated reproduction of mode which had been previously scored. 4. Mode alone correctly reproduced. This category corresponded to the one just described under 3.

Scoring of the other recall tests was simpler. A reproduction (of form or mode, respectively) was first scored for correctness, whether or not it was correctly paired. It was also scored for accuracy of pairing. We thus obtained scores for the total of correct recalls and of correct pairings in Experiments 2 and 3.

Results

The Constitutive Effect

Experiment 1. The free recall data of this experiment are summarized in Table 1. Since the scores of men and women were closely similar, they will be reported jointly.

1. The total level of recall (or the recall of F and M properties regardless of accuracy of pairing) was virtually identical in the U and non-U conditions. The mean of total recalls (see column 5) was close to the 50% level, a degree of difficulty highly adequate to the present purpose. U scores ranged from 7 to 14, non-U scores ranged from 5 to 14.

2. Accuracy of joint recall was substantially more frequent in the U condition (see Columns 1 and 2). It accounted for 76.2% of all U recalls, for 49.2% of all non-U recalls. By the Mann-Whitney test the difference is significant at beyond $p = .001$. (All tests were two-tailed.)

3. Incorrect pairing was far more frequent among the nonunitary stimuli. There was a total of nine such instances in U, of 37 in non-U; (p = .001). Two-thirds of the U *S*s did not pair incorrectly, and only one *S* did so more than once. Not only did a far greater proportion of non-U *S*s mismatch the *a* and *b* terms; they also did so more often than U *S*s.

It was stated earlier that repeated reproductions of a form or mode were not counted in the scoring. This decision had consequences for the scoring of incorrect pairings involving repeated reproductions of form or mode, which will now be described.

(*a*) When an *S* paired incorrectly a form or mode which he had previously paired correctly, it was not scored as an incorrect pairing. If, for example, the *S* had reproduced F_{10} M_9, and it was preceded or followed by F_9 M_9, the latter was counted as an instance of correct pairing, and the former was scored simply as a reproduction of F_{10}, and was included in Column 3. (*b*) Occasionally, two wrong pairings occurred involving a repetition of form or mode; for example, the reproduction of F_1 M_9, and subsequently of F_3 M_9. In that case the order of recall determined the scoring; the first wrong pairing was retained and the second one was altered to read F_3, and again entered in Column 3. (*c*) If a wrong pairing, say F_4 M_8, was followed or preceded by the isolated reproduction of F_4 or M_8, the former was scored as an incorrect pairing, and the latter was dropped out of the scoring system. Thus, the absolute number of incorrect pairings was somewhat larger than appears in Table 2; however, an uncorrected procedure of scoring would not alter the finding described above. (*d*) As implied in (*a*), an accurate pairing was scored correct without exception.

4. Recall of only one of the paired terms (of F or M alone) comprised 15.4% of all U recalls, 19.5% of all non-U recalls.

5. In the case of the isolated recalls just referred to above, U stimuli produced a small but decided preponderance of form (F) recalls, and non-U stimuli showed a similar preponderance of M recalls. This finding reappears consistently in subsequent experiments (see p. 11).

The predominance of recall of modes in the non-U condition probably reflects an actual difference of complexity between them and the forms. The necessity of preparing manageable U stimuli required the selection of the simplest modes; many of these were, moreover, highly familiar conventional symbols. Why, then, were not the modes also better recalled in the U condi-

TABLE 1

Recall Scores of Unitary and Nonunitary Stimuli
Experiment 1: Free Recall Test

	N		1 Correctly Paired Recall +(FM)	2 Incorrectly Paired Recall −(FM)	3 Recall of Form Alone	4 Recall of Mode Alone	5 Mean of Total Recall
Unitary Stimuli	24	M	7.8	0.8	1.2	0.5	10.2
		%	76.2	7.4	11.9	4.5	
Nonunitary Stimuli	24	M	4.8	3.1	0.8	1.1	9.8
		%	49.2	31.4	8.1	11.4	

Note.–Each form or mode is treated as a unit of recall. Thus the figure 7.8 in Column 1 stands for the mean number of forms and modes correctly paired; the mean number of *pairings* is one half of this value, or 3.9. This is also the way to read the entries in Column 2.

The percentage values represent the number of recall units in a given category divided by the total recall. Thus, correctly paired forms and modes in the unitary series comprised 76.2% of all items recalled.

In this and in all succeeding tables, percentage values were computed by dividing the total scores of the respective categories. These values will consequently deviate slightly from, and will be more exact than, those obtained by dividing the respective means. The total means (see Column 5) were computed by dividing the total score by N; these will therefore be more exact than the values obtained by adding the partial means.

tion? It is probable that form was the dominant aspect of the U stimulus (see also p. 30).

Experiments 2 and 3. These experiments employed two other methods of recall. As described earlier, we tested for recall of the mode given the continuous form (which we designate as F→M), and for recall of the form given the mode (or M→F), both under U and non-U conditions. In the recall test of Experiment 2, both groups of *S*s were given the forms drawn continuously, each appearing on the left of its page, corresponding to the position of the learning stimuli. In order to preserve the constancy of conditions between the non-U groups of Experiments 2 and 3, the learning stimuli were in the latter case drawn with the modes at the left and the continuous forms at the right. At the time of test the duplicates of the modes were also shown at the left, to correspond to their position during learning.

The results, which appear in Table 2, contain the frequencies of (*a*) correctly paired recalls and (*b*) of items correctly recalled but wrongly paired.

The results were markedly similar to those obtained with the free recall test of Experiment 1.

1. The levels of recall of U and non-U stimuli were very similar in Experiments 2 and 3. Again, mean recall was approximately at the 50% level.[7]

2. Accuracy of joint recall again was significantly higher in each of the U conditions. In Experiment 2, the percentage of correctly paired U recalls was 77.8, of non-U recalls 40.7% ($p = .001$). In Experiment 3, the corresponding percentages were 74.6 and 48.5 ($p = .01$). Differences in incorrect pairing, of course, were identical with those just described. These results are all the more notable when one considers that the test stimuli were identical with those of the learning series in the non-U condition, while differing from those of the U series.

3. The results obtained in Experiments 2 and 3 were closely similar. That is to say, F and M terms evoked each other with equal frequency.

[7] The scores of Table 2 refer, of course, to recall of forms *or* modes.

TABLE 2

RECALL SCORES OF UNITARY AND NONUNITARY STIMULI
Experiments 2 and 3: Paired Associate Recall Test

Condition	*N*		1 Correctly Paired Recall	2 Incorrectly Paired Recall	3 Mean of Total Recall
Experiment 2: Recall of Mode (F⟶M)					
Unitary Stimuli	12	*M*	4.1	1.2	5.3
		%	77.8	22.2	
Nonunitary Stimuli	12	*M*	2.0	2.9	4.9
		%	40.7	59.3	
Experiment 3: Recall of Form (M⟶F)					
Unitary Stimuli	12	*M*	3.7	1.3	4.9
		%	74.6	25.4	
Nonunitary Stimuli	12	*M*	2.7	2.8	5.5
		%	48.5	51.5	
Experiment 3a: Recall of Form (M⟶F)					
Nonunitary Stimuli	12	*M*	1.9	1.3	3.2
		%	60.5	39.5	

Note.–In this table the number of items recalled in a given category and the number of pairings in that category is, of course, identical.

This finding needs to be qualified at one point. We repeated the non-U variation of Experiment 3, this time placing the modes at the right, both during learning and recall; we refer to this condition as Experiment 3a. Thus, at the time of test the *S* had before him the right-hand member of a pair and was attempting to recall the left-hand member. The results, which will be found in Table 2, show that this procedure depressed recall significantly, to 57% of that obtained in the corresponding non-U variation of Experiment 3 ($p = .005$). Accuracy of joint recall was depressed absolutely but not relatively; the decrease did not reach statistical significance.

Since the conditions of learning were in all respects identical with those prevailing in the preceding experiments, the drop in recall of forms was a direct consequence of the method of test, and demonstrates that association of the non-U stimuli was polarized. Although the pairs were exposed simultaneously, and though the instructions did not weight the members differentially, they were psychologically successive, and were mastered in a left-right direction. There is no analogue to this asymmetry in the U condition. This result thus describes a further difference between the contrasted conditions: U-pairings were not polarized, in contrast to non-U pairings.

4. Experiments 2 and 3 did not produce higher levels of correct pairing than did Experiment 1. This result is somewhat surprising when one considers that recall was of the paired-associate form, in contrast to the free recall procedure of Experiment 1. It would have been reasonable to expect that some of the isolated recalls of Experiment 1 would be converted into correct pairings in the present variations. A hint of what occurred is provided by the increased frequency of incorrect pairings, both in the U and non-U variations. Apparently, aided recall introduced its own constraints; a *S* had to respond correctly at a given point, or be penalized, whereas the free recall procedure permitted him to repeat any combination of form and mode, and thus to correct his earlier responses. That the levels of total recall were closely similar to those of Experiment 1 is not surprising, since the conditions of learning were not altered.

Confirmatory Experiments

Experiment 4: Combined U and non-U Conditions. The preceding experiments compared homogeneous U and non-U series. The following variation combines these within the same experiment, a procedure that permits each *S* to serve as his own control.

From the respective series of Experiment 1 we derived two new series, each consisting of 5 unitary and 5 dual stimuli. There were two groups of *Ss*. The stimuli that were given in U form to one group appeared in non-U form for the other group, and conversely. In assigning stimuli to the two categories, we chose sets equated for difficulty on the basis of the data of Experiment 1. (The U stimuli for group 1 were: 1, 4, 6, 7, and 10.)

We also rotated the order of presentation of the stimuli, so that each stimulus would appear in each of the 10 positions. The order of presentation of U and non-U stimuli was, for the first *S*, ABBABAABBA. This order was shifted one step for each succeeding *S*.

The instructions described in detail the two kinds of stimuli, with the help of an illustrative example of each. Again, the *Ss* were set for a test of free recall. They were cautioned explicitly to "make every effort to pay equally close attention to each card."

Testing was with the method of free recall. *Ss* were urged to reproduce part of each stimulus when they could not recall it entirely and to guess when not certain. The procedure was in all respects identical with that of Experiment 1.

There were 20 *Ss*, 10 in each group, equally divided among men and women.

a. Results. The overall comparisons between the U and non-U stimuli, obtained by pooling the results of both groups, appear in Table 3.

1. The difficulty of the tasks, measured in terms of recall of content, was closely similar to those of Experiment 1.

2. U and non-U stimuli produced virtually identical total recall in one series; in the other series the U stimuli showed higher recall.

3. Under the present conditions, the differences between U and non-U stimuli in accuracy of joint recall were considerably accentuated. Correctly paired recalls accounted for 88.7% of all U recalls, for 29.3% of all non-U recalls ($p = .001$).

4. The differences in inaccurate pairing were even sharper. There was only one such instance in U, but inaccurate pairings comprised 37.8% of all non-U recalls.

5. Sixteen out of 20 *S*s were superior in pairing correctly the U stimuli; three *S*s performed equivalently; and there was one difference in favor of the non-U stimuli. (Of the *S*s who went contrary to the predominant trend, three recalled very poorly throughout, and one obtained a nearly perfect recall.)

6. Of the total of 10 stimuli, 9 produced more correct pairings in U; one stimulus failed to show a difference.

7. The reproductions showed a remarkable lack of confusion between the two sets of stimuli. (*a*) There was a total of 16 instances of incorrect pairing. Only one of these involved the combining of a form from one set with a mode from the other set; all other mispairings occurred within the same set. (*b*) Further, the U or non-U character of the correctly paired stimuli was almost faultlessly retained. In only one instance were the form and mode of a U stimulus recalled as separated; in no case was a pair of non-U stimuli reproduced in a joined manner. These results lend support to the conclusion that the boundaries between the two sets of stimuli were strong.

Under the present conditions, the differences between the stimulus conditions increased sharply, when compared with Experiment 1. It would appear that, in the competition for recall, U stimuli had a decisive advantage. This finding might be questioned if the *S*s had deliberately favored the U stimuli during learning. As mentioned earlier, the instructions attempted to guard against this contingency. As a further check, the *S*s were questioned about their learning procedure at the conclusion of the experiment. Twelve *S*s reported paying equal attention to both kinds of stimuli, 5 *S*s favored the U, and 3 reported that they had studied the non-U stimuli more carefully. According to these reports, there was no particular bias in the procedures the *S*s followed.

It may be pertinent to mention that the greater number of *S*s expressed the view that U stimuli were easier because simpler. "There was only one thing to remember in the single figures, two things to remember in the double figures"; "The double ones sort of split my attention"; "There was more to remember with the double figures—two separate objects."

The results thus confirm the main findings previously reported concerning the differences between the U and non-U conditions.

Experiment 5: Randomized Pairing of Form and Mode. In the preparation of stimuli for the preceding experiments we

TABLE 3

RECALL SCORES OF UNITARY AND NONUNITARY STIMULI

Experiment 4: Combined Unitary and Nonunitary Condition — Free Recall Test

	N		1 Correctly Paired Recall +(FM)	2 Incorrectly Paired Recall −(FM)	3 Recall of Form Alone	4 Recall of Mode Alone	5 Mean of Total Recall
Unitary Stimuli	20	*M*	4.7	0.1	0.3	0.3	5.3
		%	88.7	0.9	5.7	4.7	
Nonunitary Stimuli	20	*M*	1.2	1.6	0.5	0.8	4.1
		%	29.3	37.8	12.2	20.7	

sought to avoid combinations of forms and modes that might be similar or outstandingly fitting. Since there was no assurance that we excluded such selectiveness completely, the following variation was done as a check upon this possibility.

The forms and modes of the preceding experiments were now randomly paired. We numbered the modes from 1 to 10, drew these numbers and assigned each to the forms, in the order they had in the earlier learning series. We thus obtained a new pairing of F and M properties. Three of the original stimuli (Nos. 5, 7, and 8) were line forms; these we changed into closed areal forms (in preparation for a further variation to be described in a subsequent section). These stimuli, which will be employed frequently in subsequent experiments, are reproduced in Figure 3.

The procedure, instructions, and methods of scoring were identical with those of Experiment 1. The test was one of free recall. There were 24 *S*s in each variation, 12 men and 12 women. The summary data appear in Table 4.

1. Recall of content, or of the forms and modes, was again virtually identical in the U and non-U conditions. The mean levels of recall continued to be similar to those of Experiment 1 (see Table 1).

2. U stimuli produced far more correct pairings than non-U stimuli (65.5% and 38.1%, respectively, of all recalls: p = .001). Inaccurate U pairings were far less frequent than inaccurate non-U pairings (p = .001). As in Experiment 1, U *S*s either did not mismatch, or did so no more than once; mismatching occurred among more non-U *S*s, and with higher frequency.

3. Also in agreement with the results of Experiment 1 is the finding that isolated recalls of U forms were more frequent than of U modes, but that in the non-U series there was a predominance of recall of modes.

We have thus confirmed the previous findings, and demonstrated that the effect persists under modified stimulus conditions.

Index of the Constitutive Effect

Since the principal difference between U and non-U stimuli concerns accuracy of joint recall, it would be helpful to express the effect in such a manner as to permit comparison among different experimental conditions. One index that recommends itself for this purpose is the ratio of correct to incorrect pairings. In order to avoid complications due to zero scores, we adopted as the index the difference between correct and incorrect pairings divided by their sum. This index varies between ±1. When incorrect pairings are zero, the value is 1; when correct pairings are zero the value is

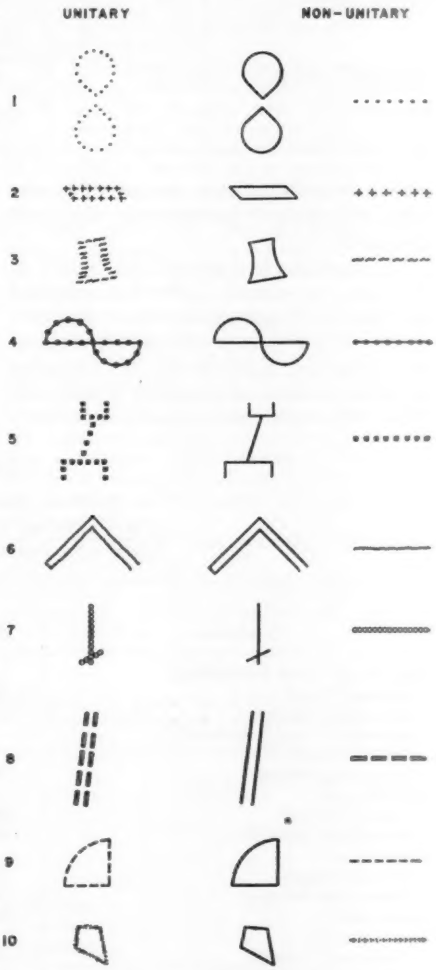

FIG. 3. Unitary and nonunitary stimulus series: Experiment 5.

TABLE 4

RECALL SCORES OF UNITARY AND NONUNITARY STIMULI
Experiment 5: Free Recall Test

	N		1 Correctly Paired Recall +(FM)	2 Incorrectly Paired Recall −(FM)	3 Recall of Form Alone	4 Recall of Mode Alone	5 Mean of Total Recall
Unitary Stimuli	24	M	6.3	1.3	1.6	0.4	9.7
		%	65.5	13.8	16.8	3.9	
Nonunitary Stimuli	24	M	3.7	3.3	1.0	1.8	9.6
		%	38.1	33.8	9.9	18.2	

−1; and the index takes on the value zero when both kinds of pairing occur with equal frequency.

We accordingly computed the values of the index for each *S*. Table 5 summarized the data for Experiments 1 to 5, and of a number of subsequent experiments employing the method of free recall. We computed the median values of the index in each condition, the proportion of *S*s with exclusively correct pairings, and the proportion of *S*s with predominantly incorrect pairings. In obtaining these values we grouped together Experiments 1 and 5, and also Experiments 2 and 3.

The U and non-U series differed consistently for all selected values of the index. The U medians of Experiments 1 to 5 ranged from 1.00 to 0.7, the non-U medians from 0 to 0.3. The proportions of +1 values

TABLE 5

INDEX OF PAIRING ACCURACY

$$\left(\frac{\text{Correct Pairings} - \text{Incorrect Pairings}}{\text{Correct Pairings} + \text{Incorrect Pairings}}\right)$$

Conditions	N	Md.	+1 Scores (in %)	Negative Scores (in %)
Experiments 1 and 5 combined:				
Unitary Stimuli	48	1.0	54	2
Nonunitary Stimuli	48	0.3	21	23
Experiments 2 and 3 combined:				
Unitary Stimuli	24	0.7	42	13
Nonunitary Stimuli	24	0.0	0	25
Experiment 4				
Unitary Stimuli[a]	20	1.0	95	0
Nonunitary Stimuli[a]	20	0.0	25	45
Experiment 7				
Unitary Stimuli	16	0.6	94	0
Nonunitary Stimuli	16	0.1	50	25
Experiment 11	24	0.0	25	21
Experiment 12				
"Coherent" Stimuli[a]	24	0.9	50	4
"Not coherent" Stimuli[a]	24	0.1	21	33

[a] Based on 5 stimuli.

and of negative values exhibited pronounced differences in the same direction.

The following analysis provides further evidence of the differences in pairing between and within units. When the method of test was that of free recall, there were instances of the isolated recall of both the form and mode of the same stimulus, or of the mispairing of either with another member of the series. The procedure of testing leaves the *S* free to pair correctly at some later point those items which he had previously recalled but not paired, or which he had mispaired. We therefore ask: When the form *and* mode of a given stimulus were recalled separately, what was the likelihood that they would also be eventually correctly paired?

Table 6, which contains the relevant data for Experiments 1 and 5, demonstrates a marked and consistent difference between U and non-U stimuli in this respect. There was a total of 10 instances in the U variation of isolated recall of form and mode of a given stimulus without eventual correct pairing of the same terms; in the non-U variations there were 42 such instances. That is to say, when both form and mode of a unitary stimulus were recalled, they were as a rule also correctly reunited; this was far less often the case for nonunitary stimuli.

Control Experiments: Recognizability and Intraserial Interference

We have inferred that the preceding results were directly a function of the respective stimulus relations—of the constitutive relation and of the relation of duality between paired heterogeneous contents. Before one can safely draw this conclusion, it is necessary to determine whether the stimulus conditions differed also in other respects, and whether the latter might be responsible for the obtained results. The present experiment and the one following are concerned with this question.

Experiment 6: Recognizability of Unitary and Nonunitary Stimuli. It is by no means established that the U and non-U stimuli were equally distinct or identifiable. The rationale of this investigation obviously requires that the experimental effect should not be a function of differences of this kind. The object of this variation, accordingly, was to compare the identifiability of the forms and modes in the two series.

a. Procedure. As the criterion of distinctness or clarity we chose the recognizability of the forms and modes. Except for the final test, the stimuli, instructions, and other conditions of learning were identical with those of Experiment 5. As before, the *S*s were instructed to pair form and mode in anticipation for a test of free recall. However, the test that followed, and which will now be described, was one of recognition.

The test booklets carried exact reproductions of each form and mode, one to a page; each appeared in the center of the page. The forms were all drawn continuously, and the modes were in linear array. Included in the test were 10 new forms and 10 new modes. The task was to check a "yes" or "no" printed on each page, indicating whether or not the given stimulus had been part of the learning series. The *S*s were informed that new stimuli would be interspersed in the test series. Again, the test of recognition came 3 min. following the presentation of the learning series.

The sequence of stimuli was as follows. The old forms and modes were each divided into 2 blocks of 5. To each of these 4 sets we added a set of 5 new forms or modes. Thus, the sequence consisted of 4 blocks of 10 stimuli, each containing 5 old and 5 new forms or modes. The order of the blocks was varied with succeeding *S*s; there was thus a total of 4 orders. Also, the order of the critical stimuli within each block was rotated from *S* to *S*; the noncritical stimuli retained the same position within a block.

The *S*s were Princeton University undergraduates, 16 in each group.

b. Results. The percentages of correct recognitions of the critical stimuli, and of

TABLE 6

FREQUENCY OF FAILURES TO PAIR RECALLED FORM AND MODE BELONGING TO THE SAME STIMULUS

	Unitary Stimuli		Nonunitary Stimuli	
	F	%	*F*	%
Experiment 1	4	4.1	16	21.6
Experiment 5	6	7.3	26	37
Experiment 7	53	38	84	70

TABLE 7

RECOGNITION OF FORMS AND MODES (in %) Experiment 6

	Critical Stimuli	Noncritical Stimuli
Unitary Stimuli		
Form	86	91
Mode	69	67
Nonunitary Stimuli		
Form	90	94
Mode	83	92

correct nonrecognitions of the noncritical stimuli, appear in Table 7.

(*a*) The level of recognition of the critical stimuli was, with one exception to be noted below, quite high. (*b*) Recognition of critical forms was superior to recognition of critical modes. By the sign test, this difference was significant in the U series ($p <$ .01), not in the non-U series. (*c*) Critical forms were equally recognizable, whether they were unitary or not. (*d*) However, the recognition of non-U modes was higher than that of U modes ($p = .02$). (*e*) Nonrecognition of the noncritical stimuli was, with one exception, slightly but consistently superior to the recognition of critical stimuli.

The test stimuli were most similar to those of the non-U series. This circumstance fails, however, to account for the difference in recognition of unitary and nonunitary modes, when one considers that the forms were equally recognizable in the two series. We conclude that there was a tendency for form to be dominant over mode in the U series. This is not surprising in the light of the distinctive functions of form and mode in the U stimulus, and of their comparative similarity of function in the non-U stimulus.[8]

While it is difficult to state precisely the relation between these data of recognition and the earlier data of recall, we may draw the following limited conclusion. Since the level of recognition sets limits to the pairings that can occur, differences of stimulus clarity did not favor the U series. If anything, the reverse was more likely the case; to the extent that this factor played a role it could only favor pairing in the non-U series.[9]

As a further demonstration of the same point, we may cite the following analysis. From the recognition data we obtained a measure of "synthetic pairing," namely, of the incidence of recognition of form and mode belonging to the same unit or to the same pair. This measure presumably sets a limit to the pairings that can occur. There were 95 such synthetic pairings in the U-group, and 122 in the non-U group ($p =$ .02). These comprised 76% of all recognitions in the U-series, and 90% of all recognitions in the non-U series. Again, we have to conclude that the conditions of registration tended to favor the non-U series; if so, the recall data of the preceding experiments tend to underestimate the effect of the constitutive relation on pairing.

Experiment 7: The Role of Intraserial Interference. It might be claimed that the stimulus series were not equally homogeneous. The non-U series consisted of forms all of which had continuous boundary lines, and of other forms all of which appeared as line aggregates. This circumstance might make them more vulnerable to intraserial interference than the apparently more individualized U stimuli.

In the variation to be now reported, the *S*s were afforded an opportunity to become familiar with the individual forms and modes prior to the main task. The procedure of familiarization raised notably the distinctness and recallability of the terms

[8] Consistent with the present data is the finding reported earlier of a slight but regular superiority of form over mode recall in the U series. The results are not, however, consistent with the corresponding finding that non-U modes were somewhat better recalled than forms.

[9] One must caution, however, against inferring too directly from recognition to recall. When the stimuli (of each series) were ranked, respectively, for ease of recognition in the present variation and for ease of pairing (in Experiment 5), the correlations were low and lacked significance.

before the main task was introduced. This step could only have the effect of reducing the levels of subsequent intraserial interference, and of equalizing the levels in the respective series. We reasoned that the experimental effect should be similarly reduced if it were a function of serial interference.

a. Procedure. The following was the procedure of familiarization. The forms and modes of Experiment 5 were drawn on separate cards, and in the positions they previously occupied—the forms at the left, the modes at the right.

One half of the *S*s were shown first the set of 10 forms, in succession. The period of exposure of each form was 4 sec. The series was shown 3 times; before each trial the order was changed by shuffling the series. *S*s were instructed to study the forms so as to be able to reproduce them correctly. The third trial was followed by a test of free recall. Thereupon, the *S*s were shown the series of 10 modes under identical conditions, and again recall was tested. The other half of the *S*s were first shown the modes, and then the forms.

After a lapse of 3 min. we proceeded to a repetition of Experiment 5. *S*s were assigned to the unitary or nonunitary groups on the basis of the preceding tests; the two groups were closely matched. The procedure of Experiment 5 was maintained without change, except that it was possible to point out during the instructions (with the help of an illustrative stimulus) the relevance of the preceding familiarization to the task.

b. Results. The procedure of familiarization produced a high level of recall of forms and modes (Table 8, first column). Further, the level of recall was virtually identical for the two groups of *S*s. There was a slight but consistent superiority in the recall of modes; for the entire group of 32 *S*s, the superiority of modes was, by the sign test, significant at beyond .01.

The data concerning pairing are also summarized in Table 8.

1. The chief finding is the superiority of joint recall in the U condition. *S*s in the latter group showed a mean of 5.3 correct pairings; the mean of non-U pairings was 2.3 ($p < .001$). Each unitary stimulus produced more correct pairings than its nonunitary counterpart.

2. Under the present conditions the U and non-U series did not produce significantly different frequencies of incorrect pairings; the respective means were 1.4 and 1.9.

Familiarization significantly raised the frequency of correct U pairings, compared with the level obtained in Experiment 5 ($p < .01$), but did not significantly alter the level of non-U pairings. Further analysis demonstrates, however, that familiarization did not alter the *relative* frequencies of accurate and inaccurate pairings in either series, in comparison with Experiment 5. In order to allow for the differences in absolute level of recall, we took the total of accurate and inaccurate pairings, and computed the proportion of each to the total. The results appear in Table 9. The ratios are substantially similar to those of Experiment 5. The differences in absolute level tell us that familiarization increased the at-

TABLE 8

MEAN RECALL SCORES OF UNITARY AND NONUNITARY STIMULI FOLLOWING FAMILIARIZATION
Experiment 7: Free Recall Test

	N	1 Mean of Total Recall before Pairing	2 Correctly Paired Recall +(FM)	3 Incorrectly Paired Recall −(FM)	4 Recall of Form Alone	5 Recall of Mode Alone	6 Mean of Total Recall after Pairing
Unitary Stimuli	16	18.0	5.3	1.4	2.4	2.6	18.3
Nonunitary Stimuli	16	17.8	2.3	1.9	4.1	4.8	17.1

Note.–The mean values in Column 1 are the recall scores obtained following familiarization and before pairing. The values f Column 6 were obtained during the final test of free recall.

TABLE 9

Proportion of Correct Pairings to Total Pairings
Experiments 7 and 5

	Correctly Paired Recall +(FM)	Incorrectly Paired Recall −(FM)
Experiment 7		
Unitary Stimuli	78	22
Nonunitary Stimuli	54	46
Experiment 5		
Unitary Stimuli	83	17
Nonunitary Stimuli	53	47

tempts at pairings, but not the proportions of the kinds of pairing.

3. It follows that isolated recalls must be more frequent in the non-U series. This was the case; the mean of isolated non-U recalls was 8.9, of isolated U recalls, 4.9.

4. The index of pairing accuracy revealed a clear-cut difference between the two experimental conditions (see Table 5).

5. Finally, we again found that when form *and* mode of the same stimulus (or pair) were recalled, they were also correctly paired with far higher frequency when unitary. Of all recalled forms and modes belonging to the same stimulus (or pair), 62% were correctly paired by the U group; this value dropped to 30% in the non-U group (Table 6).[10]

6. The total mean recall, regardless of pairing, was 18.3 for the unitary series, and 17.1 for the nonunitary series; this difference was not significant (see Table 8, last column).

These results were obtained after a high degree of familiarization with the contents of the series. There can be little doubt that this procedure, which equalized the identifiability of the stimuli for the two groups, also reduced and tended to equalize interference during subsequent pairing. Had the experimental effect been a function of interference, it should have been markedly reduced under these conditions. Actually, the effect became more pronounced. The ratio of correct U pairings to correct non-U pairings was 2.3; in the corresponding variation of Experiment 5, the ratio was 1.7.

We conclude that the experimental effect was not a function of differences of intraserial interference. Further, it seems to us that this variation, which eliminated the confounding due to the concurrent tasks of mastering the terms and pairing them, provides a more accurate approximation of the experimental effect, which the earlier results underestimated.

These findings also confirm the conclusions of the preceding variation. Equalizing the distinctness or identifiability of the stimuli had the effect of accentuating the difference between the conditions.[11]

The Scope of the Unitary Effect

In this section we continue the investigation by varying further the conditions of learning and recall, in order to establish the scope of the unitary effect.

The results so far reported were based entirely on the data of recall. In memory investigation an obvious and important distinction is that between the presence or retention of an association (or, more generally, a pairing) and its recall, since a functional connection may be present but not available. We can only conclude from what has preceded that unity was a condition favoring recall; it remains to be shown whether the effect extended to the formation proper of pairs.

[10] Table 6 shows that failures to pair were frequent in this condition, in comparison with earlier variations. This was directly a consequence of the procedure of familiarization.

[11] Why did familiarization raise the absolute level of correct U pairings, and not of non-U pairings (compared with the levels of Experiment 5)? We interpret these results in the light of Experiment 6. There we saw that the recognizability, and presumably the perceptibility, of the U modes was comparatively low. Familiarization increased the distinctness of U modes, and thus raised joint recall. But the non-U series, being more perceptible, could profit less from the procedure of familiarization.

As a first step in this direction we employed the test of *matching*. This procedure reduces considerably the burden placed upon the recall of contents. When the *A* and *B* terms are given at the time of test, the sole task of the *S*, once he has recognized them, is that of recalling the pairing they had initially. The procedure of matching thus provides a more direct test of the recall of an association, or of pairing.

Experiment 8: The Procedure of Matching—Intentional Learning. Experiment 5 was repeated with new groups of *S*s. The experiments were now done in groups ranging in size from 6 to 10.

The stimuli were projected on a screen with standard size lantern slides. The projected size of the images was controlled, by setting the width of stimulus 4 at 12 in. *S*s sat at a distance of 6 to 12 ft. from the screen. They were placed as close to the center as possible, their distance from the center of the screen not exceeding 35° — 40°. (As a further precaution, the *S*s were asked, at the conclusion of the experiment, to state in writing whether they had been able to see the stimuli distinctly; all answered in the affirmative.)

The other conditions of learning were unchanged. Learning was intentional; as before, the instructions set the *S*s to anticipate a test of free recall. An illustrative card was now introduced during the instructions, containing a unitary (or nonunitary) stimulus, in order to insure that the task would be understood (and also to make possible a comparison with a subsequent variation to be described below, which necessitated the illustrative stimulus). Also, an interval of 4 sec. was introduced between the exposures of successive stimuli, (again for the purpose of comparison with a subsequent variation that required this procedure).

A side task of anagram problems immediately followed the presentation of stimuli. After 1½ min., booklets containing the forms, drawn in continuous outline, were distributed; each form appeared on a separate page. The order of the forms was varied from *S* to *S*. A matching sheet containing the 10 modes was distributed at the same time, each drawn as a straight line. The modes were placed in a random sequence (constant for all *S*s), and were numbered in order from 1 to 10. The instructions for the matching test were then read. The *S*s were directed to turn to the first form in the booklet, to select from the matching sheet the mode that went with it previously, and to enter its number next to the form. They were to guess when uncertain, and they were free to select a given mode more than once, but they were not to return to a page once they had passed it.

When this test was completed, the matching sheets were collected. Thereupon, the *S*s were given a modified test of recognition. They were asked to inspect again the forms in their booklet, and to indicate whether they recognized each as one that had appeared in the original series by writing "yes" or "no" next to it. *S*s were warned not to alter their earlier matching responses; this they were in any case unlikely to do, since they were at this point without the matching sheets.

The *S*s were women students at Bryn Mawr College, 20 in the U variation and 19 in the non-U variation.

TABLE 10

RECALL SCORES OF UNITARY AND NONUNITARY STIMULI

Experiments 8 and 9: Matching Test

	Unitary stimuli		Nonunitary stimuli	
	N	Mean Correct Matchings	N	Mean Correct Matchings
Experiment 8: Intentional	20	6.1	19	3.2
Experiment 9: Incidental	11	4.1	15	1.7

Unitary stimuli produced clearly superior matchings, as Table 10 shows. The mean of correct U matchings was 6.1; the mean of non-U matchings was 3.2 ($p = .0002$).

It would have been instructive to compare the levels of matching with the levels of correctly paired recall in the earlier experiments. This we are unable to do, since the present procedure involved a change in the mode of exposure, and the introduction of an interval between exposures. The means of correct matchings are virtually identical with the means of correctly paired recalls in Experiment 5, but for the reasons stated we can draw no inference from this finding.

The data concerning the recognition of forms, and their relation to accuracy of matching, appear in Table 11. Failures to recognize the forms were infrequent, almost equally so in both variations, the proportions of such occurrences being 7.5% in U, and 10.0% in non-U.[12] Although the pro-

[12] Despite the small number of failures to recognize, they were not randomly distributed among the stimuli; certain forms (e.g., 1,5,6) were always recognized, by both groups; others (e.g., 9,10) produced relatively high failures to recognize in both groups.

cedure of testing suffered from certain shortcomings—it was preceded by a test of recall, and it lacked noncritical items—the levels of recognition were closely similar to those obtained in Experiment 6 (see Table 7). We did not test for recognition of modes, but it is reasonable to assume that these levels were again similar to those of Experiment 6. The results just described highlight the fact that the U and non-U conditions differed markedly in matching at the same time that they were virtually identical with respect to recognition of forms.

When unitary forms were recognized, they produced correct matches in 63.8% of the cases; correctly recognized nonunitary forms produced correct matches in only 31.6% of the cases. Thus, recognition of U forms went with correct matching in the majority of cases, and recognition of nonunitary forms went with incorrect matching in the majority of cases.[13]

The present results demonstrate that the superiority of the unitary condition persists when the burden of item recall is reduced or eliminated.

All of the preceding experiments were done under conditions of intentional learning. It would be possible to maintain that the differences obtained between unitary and nonunitary stimuli were a function of learned ways of handling the respective tasks. If so, a procedure of incidental learn-

[13] There were a number of paradoxical instances of reported failure of recognition and correct matching. In part they might be accounted for by guessing. The number of instances was small.

TABLE 11

RELATION OF RECOGNITION TO ACCURACY OF MATCHING
Experiments 8 and 9

		Experiment 8: Intentional Learning					
		Unitary Stimuli (N = 20)			Nonunitary Stimuli (N = 19)		
		Correct Matching	Incorrect Matching	Total	Correct Matching	Incorrect Matching	Total
Recognition	F	118	67	185	54	117	171
	%	63.8	36.2		31.6	68.4	
Failure of Recognition	F	3	12	15	6	13	19
	%	20.0	80.0		31.6	68.4	

		Experiment 9: Incidental Learning					
		Unitary Stimuli (N = 11)			Nonunitary Stimuli (N = 15)		
		Correct Matching	Incorrect Matching	Total	Correct Matching	Incorrect Matching	Total
Recognition	F	41	50	91	25	105	130
	%	45.1	55.0		19.2	80.8	
Failure of Recognition	F	5	13	18	1	19	20
	%	27.8	72.2		5.0	95.0	

ing should reduce the difference between them. Accordingly, we repeated the preceding experiment under incidental conditions.

Experiment 9: The Procedure of Matching—Incidental Learning. The experiments were done in groups of 4 to 8. As in Experiment 6, the stimuli were projected on a screen in a darkened room.

The task was that of judging the relative attractiveness of the forms and modes. In the nonunitary condition the *S*s stated whether the left (figure) or the right (mode) stimulus was the more attractive; in the U condition they indicated the relative attractiveness of the overall form and of its modes. An illustrative card was shown, as described in Experiment 8, in each condition. The *S*s were encouraged to judge spontaneously; the judgments were recorded on a rating sheet. A 4 sec. interval was introduced between exposures, during which the *S*s recorded their judgments. Special care was taken to insure that the *S*s would attend to the stimuli during the entire period of exposure, which was also 4 sec.

Recall was tested, after an interval of 3 min., by the method of matching. The procedure of testing was in every detail identical with that employed in Experiment 8.

The *S*s were 26 women students at Bryn Mawr College.

The results, which appear in Table 10, show that the incidental procedure markedly depressed the level of correct matching; indeed, matching of the non-U stimuli was not significantly different from chance. The differences between the incidental and intentional matchings, for the U and non-U stimuli, were significant, respectively, at $p = .03$.

At the same time the U stimuli were matched with a considerable degree of accuracy, one that exceeded significantly the level of non-U matchings. The mean number of correct U matches was 4.1, of correct non-U matches, 1.7 ($p = .01$). Indeed, the incidental matching of U stimuli was slightly superior to the intentional matching of non-U stimuli, a further indication of the effectiveness of the U condition. We consider it of interest that the U group continued to match with a substantial degree of accuracy under the incidental condition.

We again tested for the recognition of forms in the manner described for the preceding variation. Recognition of forms was somewhat, but not strongly, below the levels obtained with the intentional procedure (see Table 11). In this situation, we find that in the majority of cases recognition of form went with *failure* to match correctly. This finding is of particular interest with reference to the U stimuli (see pp. 36–39). A reference to Table 11a shows that the disparity with the synthetic measures of Experiment 6 was now quite extreme. This result cannot, as we saw, be traced more than very partially to lower recognition. We have to conclude that matching was to a considerable degree independent of recognition.

The comparison of these results with those of Experiment 8 provides particularly striking evidence of the difference between the U and non-U conditions. The levels of recognition were much the same in the two experiments, but they differed markedly in matching. Coherence of recall is not a function only of perceiving the requisite data; the perceptual relations between the data are decisive.

This variation establishes that the difference between unitary and nonunitary stimuli holds under conditions of incidental learning.

Experiment 10: Recognition of Pairing. The procedure called for the recognition of the original unit or pair. This mode of testing, which reduces to a minimum dependence on recall, should provide the clearest evidence concerning the difference between the stimulus conditions at the point of trace formation.

The experiment was done under group conditions, with 5 *S*s in each group session. The stimuli were projected on a screen in a darkened room, as in Experiments 8 and 9.

Familiarization with the forms and modes preceded the step of pairing. Here, we followed in all details the procedure described in Experiment 7. A test of recall of the single forms and modes followed the familiarization trials.

Thereupon, we proceeded to the joint presentation of forms and modes, under conditions identical with those prevailing in Experiment 5, except for the projection of the stimuli. The *S*s were assigned to the two main conditions, and were given intentional instructions appropriate to the U or non-U series. An illustrative stimulus during the instructions demonstrated the task in each condition. The test of recognition, which will now be

described, came 3 min. following the exposure of the last stimulus.

a. Recognition test. For this test each form was reproduced on a separate page with 5 different modes. For the U condition, the form was drawn with each of the 5 modes on the contour; for the non-U condition, the continuous form was paired with each of the same 5 modes. One of the five pairings of form and mode on each page was correct. The two sets of 5 modes were selected so as to be of approximately equal difficulty, on the basis of the data of Experiment 6. (Each form was paired with 5, instead of with the entire set of 10, modes in order to reduce interference at the time of test.) There was a total of 10 pages, one for each stimulus.

The order in which the stimulus appeared in the recognition booklet varied from *S* to *S*, as follows. The recognition stimuli were divided into five sets of two each. They were rotated in pairs, so that, for some *S*s, each pair was the first in the recognition series. This procedure will permit us to determine the level of recognition of the entire set of stimuli when they appear early in the series, or before interference due to the method of testing has set in.

There remains to be mentioned one further detail of importance. The order of the stimuli was also shifted during learning, and in a fixed relation to the positions they had in the recognition series. The relation of the orders was as follows:

Recognition Order	1	2	3	4	5	6	7	8	9	10
Presentation Order	4	7	6	9	1	5	8	10	3	2

We call attention particularly to the fact that the first stimulus in the recognition series was always fourth in the learning series, and the second was always seventh in the learning series. The first pair of stimuli was thus by no means in positions most immune from interference during learning.

The recognition stimuli described above were lithographed and prepared as booklets consisting of 10 pages. The *S*s were instructed to check the correct pairing on each page; they were not allowed to return to an earlier page subsequently or to correct an earlier choice.

The *S*s were 50 women undergraduates at Douglass College, Rutgers University, of whom 25 were in the U condition and 25 in the non-U condition.

b. Results. Recall of the separate modes and forms following familiarization was identical in the U and non-U groups. The total mean recall score was 18.8 in each group. This value is closely similar to those obtained in Experiment 7; again, the recall of modes was slightly superior.

Recognition of pairing was substantially and significantly more accurate in the U group. *S*s in the U group correctly recognized 77% of the stimuli; the non-U group recognized 47% of the stimuli ($p = .00005$). The median of correct U recognitions was 9, of non-U recognitions 5. The range of correct U recognitions for the several stimuli was 14–24, of non-U stimuli 7–15. Each U stimulus was superior in recognition to the corresponding non-U stimulus. Figure 4, which summarizes the last result, plots the recognition scores of the stimuli in both conditions.

Further analysis showed that the position of the stimuli in the recognition test affected accuracy. Comparing the first and last two positions, we obtain mean scores in the U series of 88 and 72%, respectively; the corresponding non-U scores were 48 and 40%, respectively.

It is of particular interest to establish the level of recognition of the *first* stimulus in each recognition test. Since the stimuli were rotated in pairs, there were only five different stimuli in the first position. In the U series, these stimuli were recognized in 96% of the cases (by 24 out of 25 *S*s); the corresponding value for the non-U stimuli was 52%. It seems noteworthy that recognition of the first stimuli in the recognition series was nearly perfect in the U series, particularly when we consider that they oc-

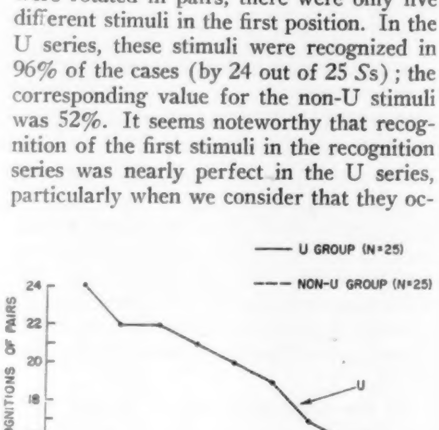

FIG. 4. Recognition of unitary and nonunitary pairs. This figure plots the number of correct recognitions of each stimulus in the unitary and nonunitary series. The stimuli were ordered in accordance with decreasing scores in the U-series. The stimuli are numbered as in Figure 3.

cupied the fourth position in the learning series, one that does not confer immunity from interference. We will consider the possible significance of this finding subsequently (see p. 38).

Figure 4 shows a definite correspondence between ease of recognizability of the individual stimuli in the two conditions. The rank order correlation between the U and non-U series was .70. Despite the systematic differences between the two conditions, the difficulty of pairing a given stimulus retained a substantial constancy.

These findings establish that the advantage of stimulus unity persisted when the contribution of recall proper was reduced to a minimum. We take this as evidence that stimulus unity favored the *formation* of functional connections.

The Figure–Ground Relation

We have studied the role of two relations: of constitution and of the pairing of spatially separated heterogeneous units. The former we took to be an instance of unity; the latter, of duality. As mentioned earlier, there are most likely other sources of unity and duality. What follows is an attempt to explore the relevance to the present investigation of another relation—that of figure and ground.

The role of the figure–ground relation in the formation of associations has not been studied or raised to the level of a problem. The reason is a paradoxical one. There has been no realization that, considered as a perceptual situation, the classical association experiment has a highly particular structure. The stimuli of the association experiment are given as pairs; pairedness is established by means of contiguity. Analysis has failed to note the following regular property of the association experiment: the paired stimuli have been universally of coordinate rank, each having the status of *figure* on the same ground.

The pertinence of the figure–ground relation to the present inquiry is quite clear. Figure and ground constitute a unit, but they are segregated subparts, differing in phenomenal and functional characteristics. A study of the coherence between figure and ground should also throw light on a question arising from the preceding experiments. The unitary and nonunitary stimuli of the preceding section differed with respect to spatial *proximity*: form and mode coincided in locus in the one case, but were separated in the other case. Therefore, the question arises whether the results obtained were a function of spatial proximity alone. An investigation of the role of the figure and ground, which involves a change of proximity relations, should clarify this question.

Experiment 11: The Relation of Figure and Ground

The general technique of this investigation can be readily adapted to the study of coherence between figure and ground. The forms of Experiment 5 were drawn in thick continuous contour. The modal properties filled the entire background, including the inner area of the form. Figure 5 provides an illustration.

The instructions, as in the previous experiments, were to study each card so as to be able to reproduce the form and its background. The conditions of learning were identical with those of Experiment 5. A test of free recall was employed. There were 24 *S*s, 12 men and 12 women. The results appear in Table 12.

1. The mean level of recall, of both men and women, was somewhat but not significantly lower than in the U and non-U conditions of Experiment 5 (see Table 4). The decrease was greater for men than for women.

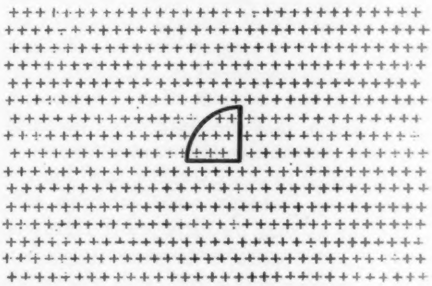

FIG. 5. A sample stimulus for the figure–ground condition.

TABLE 12

Recall Scores of Figure—Ground Stimuli
Experiment 11: Free Recall Test
($N = 24$)

	1 Correctly Paired Recall +(FM)	2 Incorrectly Paired Recall −(FM)	3 Recall of Form Alone	4 Recall of Mode Alone	5 Mean of Total Recall
M	3.3	2.3	1.8	1.5	8.8
%	37.1	25.7	20.5	16.7	

2. Correct pairings were significantly lower than in the U condition of Experiment 5 ($p = .006$), and insignificantly different from the non-U condition of Experiment 5 (see Table 4). The values of the index of pairing accuracy (see Table 6) place this condition unambiguously with all others that were nonunitary.

We conclude that the figure–ground organization acted as a *segregating* condition for purposes of association.

The results also have a bearing on the role of proximity, the investigation of which was another object of this variation. The proximity of form and modes approximated to that prevailing in the unitary condition, while differing markedly from the nonunitary condition. Nevertheless, the results were near to the latter, while departing strongly from the former condition. While this finding does not prejudge the general issue of the role of spatial proximity in association, it does suggest that the variations of proximity employed in the present investigation were without effect. The conclusion follows that the differences obtained between the unitary and nonunitary series are traceable to other sources, and that the relations of proximity were effective only in so far as they mediated other relations.

Further procedures suggest themselves that might clarify this first result concerning the role of figure–ground articulation. One obvious modification of the present procedure would be to exclude the modal stimuli from the inner area of the contour. It would be of particular interest to go one step further, and eliminate the continuous contour altogether, as illustrated in Figure 6. Part of this stimulus distribution is identical with the constitutive unitary stimulus, but the results should continue to diverge, in consistency with what we have found.

It would also be instructive, in further investigation, to fill the area enclosed by the contour with one set of modes, and the outer ground with a different set of modes.

The Relation of Inclusion

We now turn to another relation—to the inclusion of one visual form within the contour of the other. It is worth considering in its own right; in addition, it should throw further light on the role of spatial proximity under the present conditions. Finally, we will see that this variation stands in an interesting relation to Experiment 11.

Experiment 12: The Included Condition

The forms of Experiment 5 were drawn in continuous outline, and only the *inner*

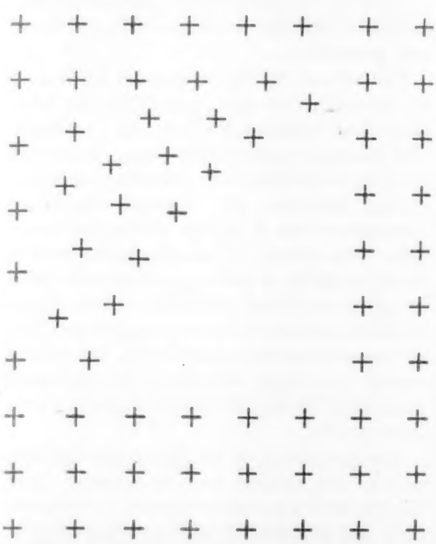

Fig. 6. A further figure–ground condition.

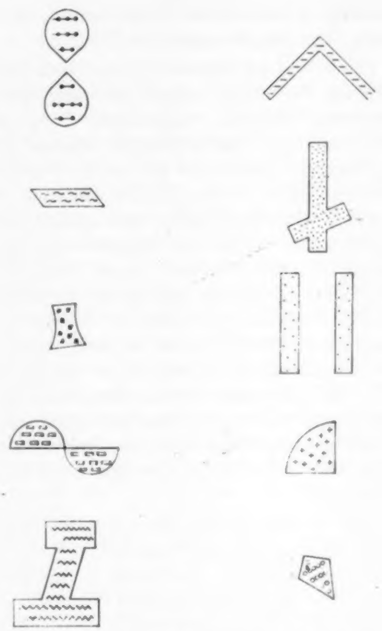

FIG. 7. Stimulus series for the included condition.

area of the contour was filled with the previously paired modes. Figure 7 illustrates the procedure. Thus, form and mode of Experiment 5 were retained, as well as the pairings.

The stimuli are reproduced in Figure 7. Each stimulus was again drawn on a white card (4 in. × 6 in.). When filling the area of a form with a modal property, care was taken to prevent the latter from touching the contour. Also, the modes were distributed, where possible, somewhat irregularly, to prevent them from outlining the form (and thus duplicating the earlier U condition). Finally, the modes filled the greater part of the area.

The *S*s were instructed to anticipate a test of free recall, during which they were to reproduce each form with its included modes. For purposes of explanation, an illustrative stimulus was prepared and shown during the instructions. In all other respects the procedure was identical with that of Experiment 5. The test employed was that of free recall. The *S*s were urged to reproduce each stimulus completely, to guess when not certain, and to reproduce the form or modes alone when they were unable to recall completely.

The *S*s were 12 men and 12 women.

Results. Total recall was somewhat, but not significantly, less than in Experiment 5, as Table 13 shows. Accurately paired recalls were 51.7% of all recalls, a value exactly between the U and non-U levels of Experiment 5 (see Table 4). It might therefore appear that the procedure of inclusion created an intermediate condition. In what follows it will be seen that this would be an incorrect conclusion.

The results contained a complicating circumstance. There were considerable differences among the stimuli in accuracy of joint recall. An examination of the stimuli raised the suspicion that they were not phenomenally of the same kind, although they had been prepared in accordance with a consistent and prescribed procedure. Some of the included modes appeared to "cohere" with their form far more than others. If this surmise should be correct, the stimuli did not constitute a homogeneous set.

To check on this possibility, we proceeded as follows. Six judges, two instructors in psychology and four graduate students, were shown individually the set of 10 stimuli spread out in a random (and constant) order. The judges, who had no knowledge of the experiment, were asked to select one stimulus the inner area of which "cohered" with the form, and another that lacked such coherence. The instructions did not attempt to define the basis of the division beyond the statement that form and mode "went better" together in some instances than in others.

TABLE 13

RECALL SCORES OF INCLUDED STIMULI
Experiment 12: Free Recall Test
(N = 24)

	1 Correctly Paired Recall +(FM)	2 Incorrectly Paired Recall −(FM)	3 Recall of Form Alone	4 Recall of Mode Alone	5 Mean of Total Recall
M	4.4	1.6	1.6	1.0	8.5
%	51.7	18.5	18.5	11.2	

Thereupon, the judges were requested to divide the entire set into two equal halves on this basis. Finally, the judges ordered the stimuli in each half according to degree of coherence and lack of coherence, respectively. We thus obtained from each judge a ranking of the entire set of stimuli on a dimension of "coherence."

We scored the stimulus selected by each judge as most coherent 10, the next 9, and so on. The scores assigned to each stimulus by all six judges were then summed. Thus, we obtained an ordering of the stimuli in accordance with a phenomenal criterion of coherence.

There was a very substantial agreement among the judges. The mean rankings of the stimuli, in the order in which they are reproduced in Figure 7, were: 2.0, 7.7, 3.7, 3.0, 6.2, 8.7, 7.5, 7.7, 2.7, and 6.0.

We then divided the stimuli into two halves of five each, in accordance with their mean rankings, and calculated the respective recall scores. Let us call the upper half "coherent" (or C), and the lower half "not coherent" (or −C). (The C stimuli were: 2, 5, 6, 7, and 8; see Figure 5.) For purposes of comparison we grouped similarly the scores of the corresponding stimuli in Experiment 5, both in the U and non-U conditions. The results appear in Table 14.

There was an impressive correspondence between the recall scores and the—independently obtained—judgments. First, the total recall of stimuli judged coherent was significantly superior to the recall of the less coherent stimuli (see Table 14, row 5). Further, this superiority was almost completely due to greater accuracy of joint recall. Correctly paired recalls comprised 67.2% of all recalls among the C stimuli, and 27.5% among the others. By the Wilcoxon test, the difference in absolute number of pairings is significant at far beyond .01. The difference is also significant when the proportion of correct pairings to total recall in every category is the score; by the sign test this difference is significant at beyond .002.

For comparison we have grouped the results of Experiment 5 similarly. Since the basis of division is irrelevant to this variation, it is not surprising that there were no appreciable differences between C and −C stimuli. Indeed, accuracy of pairing of −C stimuli tended to be somewhat higher in Experiment 5.

The principal finding is the close resem-

TABLE 14

COMPARISON OF COHERENT AND NONCOHERENT STIMULI

	Experiment 12		Experiment 5			
	Included Stimuli (N = 24)		Unitary Stimuli (N = 24)		Nonunitary Stimuli (N = 24)	
	C	−C	C	−C	C	−C
1. Mean Correct Pairings: +(FM)	3.5	0.9	2.9	3.4	1.9	1.8
2. Mean Incorrect Pairings: −(FM)	0.7	0.9	0.8	0.5	1.7	1.5
3. Mean Recall of F Alone	0.5	1.0	1.0	0.7	0.5	0.5
4. Mean Recall of M Alone	0.5	0.5	0.1	0.3	1.1	0.7
5. Mean Sub-total Recall	5.2	3.3	4.8	4.9	5.2	4.5
6. Mean Total Recall	8.5		9.7		9.6	
7. Percentage of Correct Pairings (1 ÷ 5)	67.2	27.5	60.9	70.1	37.1	39.3
8. Percentage of Incorrect Pairings (2 ÷ 5)	13.6	26.2	17.4	10.3	33.1	34.6

blance, with respect to accuracy of pairing, between the C stimuli of the present experiment and the corresponding U stimuli of Experiment 5, and the resemblance between the −C stimuli of the present experiment and the corresponding non-U stimuli of Experiment 5.[14] The values of the index of pairing accuracy (see Table 5) offer further convincing support for this statement.

Includedness per se is thus not a condition favoring joint recall. This conclusion receives support from an earlier unpublished experiment by Celeste McCollough and the writer. The association between pairs of heterogeneous nonsense figures was compared when they were spatially separated and when one appeared inside the contour of the other. No differences of association were found between these conditions.

Again, the results bear on the role of proximity. With proximity (of form and mode) equalized, there were nevertheless marked and consistent differences between the two subgroups that were discriminated on a phenomenal basis. Proximity clearly cannot account for this result. Further, we have also found that, with respect to pairing, the C stimuli of this series were similar to the U stimuli of Experiment 5, and that the −C stimuli resembled the non-U stimuli. This result suggests that the differences in pairing between the U and non-U stimuli were also not a function of proximity. (For a further discussion of this point see pp. 31, 34.)

We also note that, as a consequence of the relation of inclusion, all stimuli of this experiment were phenomenally of the "one" variety. If so, membership in a "single" perceptual constellation is not a condition that favors pairing. We need to distinguish between the property of "singleness" and the quality of unity. The difference between the unitary and nonunitary stimuli of the earlier experiments is therefore not adequately described in terms of the difference between "one" and "two" either. Indeed, it can be readily shown that neither proximity nor numerical unity are decisive for figural unity.

What, then, is the perceptual difference between the stimuli we have called "coherent" and "not coherent"? To us it seemed that the form and contour of the stimuli judged coherent participated in the formation of a unitary ***surface***. In these cases the filled area was seen as belonging to the form. In the other cases the inner area was seen simply as filled with forms of a particular kind; the contour and the enclosed shapes had distinct identities. If this interpretation is in the right direction, the C stimuli were phenomenally and functionally unitary, in contrast to the −C stimuli, and the present results provide independent evidence concerning the effect of perceptual unity on pairing.

It is a question for separate investigation to establish the stimulus conditions of surface formation in this case. The present study provides only tentative hints. It seemed to us that the less individual the modes were as forms in their own right, the better they lent themselves to this effect; thus, dots and stippled areas were judged predominantly coherent. It is also probable that the size of the included forms and the uniformity of their distribution, as well as their figural relation to the including form, play a part.

It also follows that the specific sources of phenomenal unity are diverse. According to the interpretation here offered, in the case of the C stimuli, includedness mediated a particular organization, namely, the formation of a surface, just as the relation of constitution mediated the phenomenal unity of the stimuli of the preceding experiments. It would appear that the complete spatial coincidence of two properties is one condition of unit formation. Correspondingly, nonunity, under certain conditions, may be achieved by spatial separation, and also by failure of surface formation.

The present experiment stands in an interesting relation to Experiment 11. Viewed in a certain way, they are identical in this

[14] As mentioned above, the C and −C stimuli differed also in general level of recall. We have no explanation for this result. The combined condition may have accentuated the difference between the two subsets. We found some evidence of the same trend in Experiment 4.

respect: both have continuous forms with modes filling the inner area. The difference between them is equally clear: in the present experiment the modes were confined entirely within the contour, whereas in Experiment 11 they extended into the background. The following comparison between them seemed, therefore, worth attention.

We have just identified two subsets of stimuli—coherent and not coherent—that differed markedly. Let us now observe the performances on the corresponding subsets of the figure–ground condition. The results appear in Table 15.

The difference between coherent and not coherent stimuli disappears completely when the modal components extend into the ground. The finding that the interaction between a contour and included modes is abolished when the latter are also part of the ground makes good sense from the standpoint of perception. When the modes are part of the ground, those falling within the contour lose their specific relation to it, and become a mere continuation of the ground. Thus, we have established a difference between the relation of inclusion and the figure–ground relation.

This investigation has provided further confirmation of the role of stimulus unity. The difference between the more and less unitary stimuli corresponded to those of the earlier experiments. The specific grounds of unity were different in the present setting, but the consequences for joint recall were quite similar.

Experiment 13: A Variation of the Included Condition

As a check on the preceding results, Experiment 12 was repeated with a new pairing of forms and modes. The forms and modes were those of the preceding variation, but the pairings were now those of Experiment 1.

The procedure described above was followed without change. Again, the stimuli were judged by a (new) group of 6 judges for "coherence." The *S*s were 24 Swarthmore College students, 12 men and 12 women.

The results were in all essentials similar to those of Experiment 12. The new sets of C and −C stimuli differed markedly in total recall and in accuracy of joint recall. By the Wilcoxon test the difference in absolute number of pairings was significant beyond .01. Correct pairings accounted for 70.8% of all C recalls, for 46.5% of all −C recalls. The ratio of correct pairings to the total recall score of each *S* was also computed for each *S* in each category; by the sign test, $p = .03$.

TABLE 15

COMPARISON OF COHERENT AND NONCOHERENT STIMULI

	Experiment 11 Figure-Ground Stimuli ($N = 24$)		Experiment 12 Included Stimuli ($N = 24$)	
	C	−C	C	−C
1. Mean Correct Pairings: +(FM)	1.4	1.8	3.5	0.9
2. Mean Incorrect Pairings: −(FM)	1.0	1.3	0.7	0.9
3. Mean Recall of F alone	1.0	0.8	0.5	1.0
4. Mean Recall of M alone	0.8	0.7	0.5	0.5
5. Mean Sub-total Recall	4.2	4.6	5.2	3.3
6. Mean Total Recall	8.8		8.5	
7. Percentage of Correct Pairings (1 ÷ 5)	34.0	40.0	67.2	27.5
8. Percentage of Incorrect Pairings (2 ÷ 5)	24.0	27.3	13.6	26.2

These results actually underestimate the difference between C and −C stimuli. While the judges were consistent in differentiating between the extreme stimuli of this series, they were far more variable when it came to the 4 middle stimuli. The mean rankings of the latter were very close to each other, attenuating the effect. When we compared the three stimuli at each extreme, correct C pairings accounted for 70.6% of all recalls, and correct −C pairings accounted for 37.3% of all recalls. The results substantially confirm the findings of Experiment 12.

We have also asked whether the same modes and forms were judged coherent in Experiments 12 and 13. As might be expected, the modes proved more decisive. Three modes (dots, dashes, and stippled areas) produced high judgments of coherence when they filled the areas of different forms. As mentioned earlier, the lack of individuality of the modes, and the homogeneity of their distribution, was probably responsible for the impression of areal homogeneity, and consequently for surface formation.

Experiment 14: A Further Variation

The principal result of Experiments 12 and 13, namely, the difference that emerged between stimuli judged "coherent" and "not coherent," is susceptible of another interpretation. We have seen that the former generally contained modes of relatively homogeneous distribution. This suggests the possibility that modes belong to "coherent" stimuli duplicated the shape of the contour. If so, the advantage they had may not have required the participation of the boundary line. The modes in question would then represent a modified version of the earlier U stimuli, while the −C stimuli would correspond to the earlier non-U condition. Consequently, the interpretation advanced above would be incorrect. The present experiment was designed as a check on this possibility.

The stimuli of Experiment 12 were modified as follows. Each card consisted of a pair of separated stimuli. The stimuli at the left were the continuous forms of Experiment 12, those at the right were the arrays of modes which belonged to that form. The latter were grouped precisely in the way they were previously. Thus, the stimulus contents were identical with those of Experiment 12, except that the modes were now separated from the contour.

The *S*s were given free recall instruction. In addition, the instructions specifically called attention to the similarity of shape between the terms, as the following statement shows: "Each card will contain two figures. One will be that of a simple outline form at the left; and the other will be that of a number of smaller forms grouped together at the right. It will help you in remembering the pairs later to notice that the smaller drawings at the right have an overall shape quite similar to the one at the left. I want you to look at the drawings carefully so that later you will be able to draw from memory as many of the pairs as possible." A free recall test followed.

If similarity of form between contour and modes was responsible for the difference between the "coherent" and "not coherent" stimuli of Experiment 12, this difference should also appear under the present conditions. If the difference between the two sets of stimuli should disappear, the conclusion would be in order that "coherence" in Experiment 12 was mediated by the surrounding contour.

The *S*s were 7 men and 5 women students at Swarthmore College. The results, which appear in Table 16, contain the data for the stimuli which had been categorized in Experiment 12 as "coherent" and "not coherent."

Mean recall was closely similar to that obtained in Experiment 12. The proportion of correct pairings to recall, for the entire series, was somewhat lower; there was also a higher level of isolated recalls.

The C stimuli did show a trend toward more accurate pairing than the −C stimuli, but the difference was small and not significant; the effect was far weaker than in Experiment 12. There was no difference between C and −C stimuli in inaccurate pairing, in contrast to the results of Experiment 12.

The results do not convincingly support the view that the advantage of the "coherent" modes is to be traced to their form quality, and that this accounts for the findings of Experiments 12 and 13. It should be added that the present variation may have been weighted too one-sidedly against the surface formation alternative. The pro-

cedure of separating the continuous contour from the mode aggregates, it seemed to us, enhanced the perceived form similarity between them beyond what was the case in Experiments 12 and 13, in addition to which the instructions explicitly stressed this relation of similarity. Nevertheless, given our lack of knowledge concerning the interaction between a contour and its included modes, one must reserve a final conclusion.

We can, however, draw the lesser conclusion that the factor of proximity was not responsible for the differences obtained between the unitary and nonunitary stimuli of the earlier experiments.

Interpretation and Discussion

We have studied an aspect of coherence that has not hitherto claimed attention. Theory and investigation in this region have placed in the forefront the role of conditions such as temporal contiguity and frequency. This investigation was concerned with a different question, namely, with the role of different kinds of stimulus relations in establishing coherence.

Accordingly, we compared the formation of functional connections between stimuli whose relations were varied in a number of ways. The stimuli were heterogeneous visual forms, and the relations between them were as follows: they were spatially segregated units; they belonged to the same visual contour, being in a constituent–whole relation; the boundaries of one surrounded the other; one had the function of figure, the other of ground. These conditions differed in important ways. More particularly, they could be grouped on the basis of the memory data in two categories. One set of conditions produced markedly superior connections, the other was more resistant to their formation. Table 17 summarizes the findings for the entire range of conditions.

The two major groupings include relations of considerable diversity. We proposed that the basis of division was the property of unity, that unitary stimuli were superior in establishing functional coherence.

What grounds are there for identifying a given stimulus distribution as unitary? To avoid circularity the decision, of course, must be independent of the memory data. We relied in the first instance on phenomenal evidence. The division of the stimuli on a phenomenal basis was straightforward. In some of the instances studied, special inquiry was unnecessary. Most, if not all, observers would agree to call a set of repetitive modes delineating a shape unitary, and the spatial separation of these from a continuously outlined shape dual (as in Experiments 1–10); at least they would agree that the former are more unitary than the latter. There would be similar agreement that the figure–ground distributions in Experiment 11 are less unitary than the forms delineated by modes. In other instances that were less clear, phenomenal judgments were systematically obtained for the purpose; this

TABLE 16

Comparison of Coherent and Noncoherent Stimuli
Experiment 14: Free Recall Test

	C		−C
1. Mean Correct Pairings: +(FM)	2.2		1.3
2. Mean Incorrect Pairings: −(FM)	.5		.3
3. Mean Recall of F alone	1.0		1.4
4. Mean Recall of M alone	.7		.9
5. Mean Sub-total Recall	4.4		4.0
6. Mean Total Recall		8.4	
7. Percentage of Correct Pairings (1 ÷ 5)	49.1		33.3
8. Percentage of Incorrect Pairings (2 ÷ 5)	11.3		8.3

TABLE 17

SUMMARY TABLE OF RECALL SCORES OF UNITARY AND NONUNITARY STIMULI (in %)

Unitary Stimuli			Nonunitary Stimuli		
Experiment	Correctly Paired Recall	Incorrectly Paired Recall	Experiment	Correctly Paired Recall	Incorrectly Paired Recall
1	76.2	7.4	1	49.2	31.4
2	77.8	22.2	2	40.7	59.3
3	74.6	25.4	3	48.5	51.5
4	88.7	0.9	4	29.3	37.8
5	65.5	13.8	5	38.1	33.8
12:C	67.2	13.6	12:–C	27.5	26.2
			11	37.1	25.7

Note.–The experiments included in this table employed the method of free recall, except for Experiments 2 and 3, which employed paired-associate recall.

was the case with the inclusion of modes in the area bounded by a contour (see Experiments 12 and 13).

Since the objective stimulus properties in most cases can be specified exactly, it is possible to relate them to phenomenal unity. Accordingly, we can say (*a*) that the relation of constitution is a condition of phenomenal unity, (*b*) that the spatial separation of nonsimilar forms is a condition of duality, as is also (*c*) the presence of hetergeneous forms in the relation of figure and ground. The stimulus conditions adequate to surface formation, as we have seen, await further investigation.

Implicit in this discussion is the assumption that unity (and duality) has its source in different specific conditions, some of which we have doubtless not mentioned. The question arises whether the general category of unity, when applied to instances as different as those here considered, and to others that were not considered, has a concrete content. It is not possible to specify at present an objective stimulus property shared by all instances experienced as unitary or dual, respectively. Would it therefore not be simpler to describe the results in terms of the objective characteristics of the stimulus and to forego reference to a property that can only be identified phenomenally? Such a procedure would leave entirely unexplained the fact that each set of diverse stimulus relations produced consistently similar results. Although the grounds of phenomenal unity require further investigation, they should not for that reason be ignored. It may well be that the phenomenal evidence is in advance of what we are at present able to formulate in other terms.

A further question will have to be faced in connection with the property of unity. There may be grounds for holding that any two stimuli, however heterogeneous, constitute a unit, when they are the only items in the field. Another way of stating the same point would be to consider that any pair of units may form a single pattern. It would follow that the stimulus conditions we are contrasting are all unitary, and that they differ mainly in degree of unity. If so, the question we have put would concern differences between more or less unitary conditions, or between units differing with respect to the autonomy of their subparts. It is of considerable importance to establish whether the difference in question is only one of degree, and we will consider this point subsequently (see pp. 39–43). However this issue is decided, the main outcome of this investigation remains unchanged. It has

demonstrated that the coherence of data in memory is a function of their unit relation.

The findings are restricted to a particular modality—the visual—and to a limited set of properties within the modality, and therefore need to be verified in other settings. But they provide the basis for a general conclusion: whenever we can specify the relative unity of two stimulus distributions, we can predict their relative coherence.

In what follows we will explore further the conclusion just stated, including its bearing on the nature of associations.

Alternative Interpretations

The procedure we have followed was to relate differences of recall to given stimulus conditions. It is necessary, therefore, to establish whether stimulus properties other than those we have identified might have been responsible for the findings. This question has concerned us earlier; we will now consider it more systematically.

1. One obvious requirement of this study is that the respective stimulus conditions be equally perceptible or discriminable. In the light of the results already reported, this requirement can be modified as follows: differences in perceptibility must not favor the conditions that are superior in coherence. Experiment 6 demonstrates, we believe, that this requirement was met. There, we employed recognition (of forms and modes, respectively) as an index of perceptibility. (*a*) The main finding was that the nonunitary stimuli (in particular the modes) were somewhat more recognizable. This circumstance should favor the joint recall of nonunitary stimuli. Nevertheless, the unitary condition was superior with respect to joint recall. (*b*) It might be maintained that the issue concerns the perceptibility of the entire stimulus, or the perceptibility of the given relation. For example, was the constituent–whole relation more easily discriminable than the relation of adjacency between heterogeneous forms? Such threshold differences could determine the memory results.[15] In this connection we would cite the "synthetic pairings" of Experiment 6, or the instances of *joint* recognition of the form and mode of a given unit or pair (see p. 14). Such joint recognition was more frequent in the nonunitary series. We take this result to mean that the threshold of perceptibility was lower in the nonunitary series. (*c*) Experiment 7 provides evidence in the same direction. The procedure of familiarization there employed raised the recognizability of the forms and modes to a maximum and also equalized it for the two conditions. The persistence (and increase in magnitude) of the experimental effect under these circumstances is convincing evidence that differences of discriminability were not responsible for the results.

2. The rationale of this study requires that the conditions be equivalent in content, or in "amount" of information. No finding is more clearly established than that it is more difficult to master more material than less. When two otherwise similar tasks differ in ease of mastery, the question immediately arises whether they differ in "amount to be learned."

a. The assumption of such a difference may take the form of asserting that the unitary series consisted of single stimuli, and the nonunitary series, of pairs; or that the latter contained twice as many stimuli as the former. This formulation begs the question. It ignores the fact that each condition contained forms and modes, that these were heterogeneous, and that one could not be deduced from the other in either condition. The assertion is actually an outcome of the correct intuitive inference that the unitary condition is the easier, and of the unexamined assumption that the responsible difference is one of amount of material.

b. The following is a more serious version of the same point. The nonunitary stimuli consisted of pairs, each with its form and mode. The *a* term was a particular form delineated by a continuous mode; the *b* term also had a particular shape, that of a straight line, and was composed of modes. Thus, each pair contained two forms and two modes. The unitary stimuli, how-

[15] The writer is grateful to E. J. Gibson for calling attention to this point.

ever, eliminated the continuous mode and the linear shape.

Two points might be made in answer. First, the nonunitary *S*s knew from the start that the stimuli would consist of continuous forms paired with lines; they did not need to learn about this feature of the task. It must be admitted, though, that this is not a conclusive reply; the fact remains that the nonunitary series contained data absent from the unitary series. Second, and more weighty, is the consistent finding that the conditions were very similar in content recall. This result goes counter to the interpretation that a quantitative difference of material was responsible for the observed effect.

3. A more plausible objection is that the unitary stimuli were less homogeneous, and therefore less vulnerable to mutual interference. Each condition had a *series* character. In particular, the nonunitary set contained two well-defined series—continuous forms and straight lines. The members of each of these series, by virtue of similarity, may have been more exposed to interference than those of the unitary series. Although this homogeneity did not impair recall of content, as we saw earlier, it is quite possible that it contributed to associative interference.

It was in this connection that we performed a control experiment employing the procedure of familiarization (Experiment 7). This experiment provided strong evidence that differences of intraserial interference do not account for the results. Familiarization raised the recall of forms and modes to a near maximum prior to the main task, equalizing the availability of the items in the respective conditions. This could only have the effect of reducing the importance of any differential interference at the time of learning. If interference had been responsible for the results, differences between the two series should have been reduced. The opposite was the case. (It should be added that if we had obtained evidence for the differential role of interference, this would not have necessarily resolved the issue. It would still remain to be decided whether the interference in question was a cause of the experimental effect, or a consequence of the unit relation.)

Here also should be mentioned the experiments involving the relation of inclusion. The presence in the series of dense fields of modes, in accordance with the argument, should have made for very considerable interference; the clustered modes were as homogeneous as their counterparts in the nonunitary series of the earlier experiments. The results support the interpretation that it was the relation of form to modes which exerted the decisive effect.

Finally, it seems appropriate to caution against too ready an acceptance of the relevance of an interference interpretation for data such as these. It seems to us more tenable that the poorer performance in the nonunitary condition was a direct consequence of the greater resistance these stimuli offered to the formation of associations, and possibly of their lower resistance to disintegration.

4. Unitary and nonunitary stimuli differed with respect to the spatial proximity of forms and modes. If we had to rely on the data of Experiments 1 to 5 alone, it would be a tenable conclusion that spatial proximity was responsible for the results obtained. Accordingly, we altered the proximity of forms and modes in Experiments 12 and 13. Although these variations equalized the proximity relation for all members of the series, they produced two sets of stimuli differing appreciably in pairing. One of the sets gave pairings quite comparable to those obtained with the nonunitary stimuli, despite the evident differences between them in proximity. Finally, the results of the figure–ground variation of Experiment 11 resembled closely those found with the nonunitary stimuli, although the two again differed in proximity.

We thus found that conditions identical in spatial proximity differed in joint recall and that others differing in proximity were equivalent in this respect. Proximity cannot account for these results. Whatever the effect of proximity per se might be, other circumstances must be in large part respon-

sible for the present findings. The interpretation we propose is that spatial proximity was of consequence in this investigation only insofar as it affected the property of unity, and that differences of proximity were otherwise without appreciable effect.

5. A related question is whether the contrasted conditions differed with respect to the temporal character of the stimulation. In the unitary case form and modes were most likely perceived simultaneously or nearly simultaneously, but they may have been apprehended in a more successive way when they were spatially separated. Indeed, one finding reported earlier may seem to point in this direction (see Experiment 3a), and to suggest that a division of attention played a part when the stimuli did not occupy the same position.

Differences of temporal stimulation, we believe, cannot account for the results. First, in the included and figure–ground conditions, form and modes occupied the same regions, a circumstance that should have reduced successiveness, but the results do not go in the presumed direction. Second, there is no convincing reason for the belief that present differences of temporal successiveness could be responsible for the order of effects obtained in experimentation of this kind. Finally, successiveness of apprehension, to the degree it played a part, may itself have been a consequence of the perceived lack of unity.

6. It is reasonable to ask whether unitary stimuli lent themselves more easily to mnemonic devices. A unitary stimulus might be more likely to resemble familiar objects. Also, it might be verbally describable in a more concise way than a pair of stimuli; thus, the designation "dotted circle" is perhaps easier to recall than "circle and dots." If so, the experimental effect would be only indirectly an effect of the perceptual properties in question, and a direct consequence of the intervening verbal operations.[16]

Our observations showed that labelling did occur with some frequency, though by no means uniformly. We have no evidence that the conditions differed systematically in the manner suggested above; it is unlikely that this was the case. (*a*) Perhaps the most convincing evidence against this interpretation comes from Experiment 9, which employed a procedure of incidental learning. The latter should have decreased the use of labelling in both conditions, and consequently the magnitude of the experimental effect. This was not what we found. (*b*) This interpretation cannot readily account for the differences between the "coherent" and "not coherent" subgroups of Experiments 11 and 12.

7. Finally, it may appear that the findings can be interpreted in terms of Thorndike's factor of "belonging." It is clear to us that this is not the case. The nonunitary conditions of this study conformed completely to the requirement of belonging, in the sense of Thorndike, fully as much as the unitary conditions. Thorndike (1932) restricted belonging to the realization that "this goes with that," expressly asserting that it referred to "nothing logical, or essential, or unifying. . . ." (p. 72). It would therefore be confusing to identify belonging with the relation of unity.

Let us summarize the central issue of this section. We have found that a unitary stimulus joins its parts more intimately, or that one can go, in recall, from one aspect of it to another more easily than one can from one unit to another. What, we may ask, is the selective principle responsible for this advantage? Is unity per se a condition of coherence? Is it an irreducible datum, or can its effects be derived from other determinants? More particularly, can these effects be referred to conditions that are only concomitant with unity, and which themselves lack organizational character? Had we demonstrated that these other conditions could account for the results, the significance of the investigation would have shifted appreciably. To be sure, it would still be a matter of interest to have shown that unity implies the presence of other

[16] One may ask, though, whether the assumption that the one verbal phrase is more effective than the other does not presuppose the very principle that is in question.

characteristics important for learning and recall. But in that case the relation of consequence would be between the data of recall and properties such as intraserial homogeneity or perceptibility; the condition of unity would have become merely an index of the presence of these other properties.

It is hardly our purpose to suggest that the consequences of unity are not susceptible of further analysis. The preceding examination demonstrates that certain particular interpretations are not valid, and raises the presumption that the search for an answer will have to take relational properties of the stimulus into direct account.

Sources of Perceptual Unity

We would like to understand better the grounds for the fact that a unitary stimulus joins its parts more intimately, thus producing characteristic effects in memory. An answer requires a more detailed study of the stimulus. The following is an attempt to re-examine the stimulus relation that was here most extensively studied, that of form and mode on a contour line.

It should first be understood that the relation of form and mode is not an instance of any of the grouping principles described by Wertheimer. These principles referred entirely to what we have here called the property of form. To be sure, Wertheimer often illustrated these by means of patterns of dots, the latter functioning as modes. His concern, however, was solely with the particular grouping that was realized out of the alternatives that were theoretically possible. For this purpose the character of the modes was of hardly any account. In contrast, the question we have raised concerns precisely the relation between the form that is generated by modes that "carry" the form.

It is also important to observe that the relation of form to mode is not a usual instance of a part–whole relation. A mode is not part of an encompassing form in the same sense that a side is part of a square. This follows from the fact that the modes contribute to the form primarily by virtue of their position; they have the function of points in generating a form. The specific shape of the mode is far less relevant for this purpose. This can be easily demonstrated. Different modes can serve to delineate the same form (see Figure 1); in these cases there is no difficulty in identifying the constant form. Conversely, the same modes can delineate different forms; and again one notes readily the identity of modes and difference of forms.

We have called the relation of form and mode one of constitution, since the modes are strictly constituents of the form. The relation is also one of *dependence;* one aspect of the stimulus requires the other. It is probable that stimuli identified as unitary are as a rule dependently related, either in the sense that one cannot occur without the other, or because they alter each other. In that case the distinction between a unit and a duum would be clearly defined: the latter would involve nondependence and absence of (or extremely weak) mutual modification.

At this point we may venture a further step, based on the observation that form and modes were identical in locus. The form–mode relation may be a special case of a general principle which can be stated as follows: *The spatial coincidence of any two properties or aspects is a sufficient condition of unity.* Actually it is not certain that the form–mode relation is one of coincidence. The following would provide a more decisive test of the principle stated above. Let one stimulus series be a set of colored forms, each on a white ground. That is to say, the area of each form is of a homogeneous and distinctive hue. Let the memory task be that of recalling (or matching) the hue of each form. One can construct a parallel series of identical forms, with the ground of each in homogeneous and distinctive hue, while the inner areas of the forms are white. The first series is an instance of coincidence of color and form, in contrast to the latter. In terms of the principle stated above, the first stimulus series should be superior in matching form with hue.[17]

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[17] Experiments employing this procedure will be reported subsequently.

It would be an error to consider the principle of spatial coincidence an instance of a law of proximity. The latter (for which we have found no support under the conditions of this investigation) presumes a continuous relation between distance and a given psychological function. We have seen, though, that there develops a strong difference between complete spatial coincidence and a condition that departs only slightly from it (compare Experiment 1 with Experiments 11 and 12).

We have not attempted to explain why the relation in question favored functional coherence. Given the restricted degree to which form and mode alter each other, the strength of the obtained effect is indeed impressive. The following remarks are intended only as suggestive.

First, we note that the modes of this investigation had two properties: they were forms, and they functioned as points in generating a form. To us it seems deserving of investigation to establish whether a *double function* is a condition favoring coherence. At present, there is no evidence on this point.

Second, it may be going too far to say that form and mode do not interact. Some modes may well be more compatible with a given form than other modes (see Figure 8). Thus, a circular mode (Figure 8a) tends to blur an angular form such as the triangle, especially at the apex points, but is less affected by angular modes (see Figure 8b). At the other extreme, there is an outstanding relation of fittingness between a form and a mode of the identical form (see Figure 8c). At the same time, modes with least individuality as forms in their own right, such as dots and continuous lines, least disturb the form property (see Figures 8d and 8e), and are suitable for the delineation of all shapes.

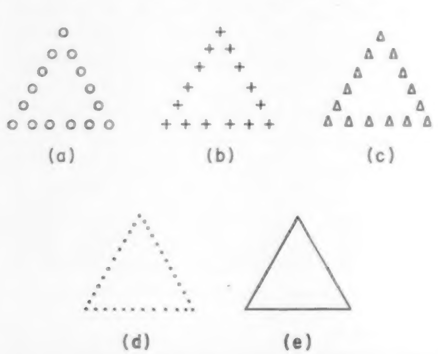

FIG. 8. Compatibility of form and mode.

Although there is no advance relation of requiredness between form and mode, they may be more or less compatible once they are paired. Thus, compatibility may introduce a more intrinsic relation between form and mode. Also, the possibility arises that in the unitary condition the *S* is more directly centered on the relation between form and mode. For example, he may be sensitive to the fact that a curved form is carried by angular modes. This formulation does not explain away the obtained difference between the unitary and nonunitary stimuli, since a difference of sensitivity of the kind here assumed would itself be a function of the property of unity. In addition, it is doubtful whether such distinctions can adequately account for the order of the obtained effects.

Finally, it is a question for separate investigation whether the more usual category of part–whole relation produces effects similar to those under discussion. The interpretation put forward in this study, namely, that perceptual unity is a condition of coherence in recall, requires an affirmative answer.[18]

This discussion may serve to illustrate the fruitfulness for the present problem of an analysis of the stimulus. (*a*) The constitutive relation was distinguished from the part–whole relation and from the conditions of perceptual grouping hitherto studied. (*b*) We have shown that the constitutive relation is one of dependence, and suggested that dependence may be a property of unitary stimuli generally. (*c*) A principle of spatial coincidence was stated as one condition of phenomenal unity. (*d*) The question was raised whether the presence of a double function favors coherence. (*e*) The relevance

[18] Experiments dealing with this question will be reported subsequently.

of the part–whole relation to the present problem was described, and shown to furnish a test of the general interpretation growing out of this investigation.

Perception and Association

This investigation deals with the relation between perceptual properties and coherence as evident in the data of memory. It therefore makes contact with the older problem of the relation of perception to association. The major theories of association have at this point followed different, indeed opposed, assumptions. These we will now examine, in order to see their relation to the present problem.

1. What one may call associationistic doctrines of association hold to a sharp separation between perception and association. This is a direct consequence of the historical fact that these doctrines started with the assumption that psychological contents were sense data, which had the status of independent, irreducible elements. This starting point dictated the scope and conception of the associative process. In the first place, it was to association that one had to turn for the explanation of order in mental life. Sense data, being discrete, lacked order; they had to be combined into stable sequences, and this was the function of association. There were thus two major problems for this psychology: the identification and description of the sense data or elements (and eventually the study of the physical energies that are their adequate stimuli), and the investigation of the manner in which they become joined. The fundamental task of associationistic inquiry was to account for the joining of one sense datum to another, the process that was held responsible for the constitution of psychological objects, and in general for the principles of order that unorganized sense data lacked.

Given the sense data thesis, a number of consequences followed for the interpretation of association as a process. If the function of association was to join data that are initially unconnected, then the noting of sense data was one kind of event, the association of them another. On this basis an association was conceptualized as the formation of a bond or pathway between unchanging contents, and independent of the character of the contents. Some associationistic theorists, such as John Stuart Mill, were not content with this formulation, suspecting that association often produced a more intimate joining of contents. It was in this connection that the notions of "fusion" or "mental chemistry" were brought forward, but the problem was not to be faced until the appearance of the gestalt theory of perception.

This sharp separation between the data and their association served as the theoretical basis for the experimental study of associations. Let it be noted that, in terms of the present discussion, an association has been historically conceptualized as a process occurring *between units;* the sense data of associationism were discrete, sovereign units. The experimental movement left this assumption untouched. To be sure, the actual study of associations has rarely worked with elements; typically, the procedure has been to establish associations between complex contents. But the failure to question the traditional assumption had the following consequences. First, association was always studied between distinct units. Thus, the prevailing assumption perpetuated a uniformity of procedure and discouraged efforts to vary deliberately the relations between the terms that were brought into association. Second, it forestalled questions about the properties of the stimuli that were studied. The study of associations has largely taken the stimulus for granted, concentrating on the connections alone. The result was to maintain the sharp separation between perceptual and associative operations.

The subsequent advances in the field of perception, and in particular the study of unit segregation and formation, have not introduced any substantial modification into this traditional position. The investigator may assume that principles of perceptual organization determine the formation of units. But these perceptual events, he holds, serve only to set the stage for the subse-

quent, and wholly different, associative operations. Perceptual conditions may determine the identifiability and clarity of the stimulus, but association proper is an activity following its own laws. This is in effect to deny a *direct* influence of perceptual relations on association, while acknowledging that perceptual conditions exert a limiting effect on associative operations. The latter, to be sure, must work on what is perceptually given; perceptual principles decide what the units are, or *what* will be associated. But once these conditions are given, associative operations enter that are autonomous. Thus, the data of perception play a role in current associative thinking analogous to that of the elements in the earlier forms of association doctrine.

The findings of this investigation, which establish a relation between perceptual properties of the stimulus and functional coherence, raise the following questions for the position of associationism. If the phenomena here studied are all instances of one process, it becomes necessary to revise current associative formulations at a decisive point, and to assert that ***perceptual relations exert a DIRECT effect on the formation of associations.*** This conclusion would come into doubt if it were established that the coherence of terms within a unit is different in process from the coherence between one unit and another, a question to be discussed in the following sections. In that case, it would be necessary to conclude that the traditional study of association has dealt with a restricted question, that it has not encompassed the full range of functional connections, and that the stimulus conditions for association must be specified in perceptual terms.

2. The gestalt studies of perception of the last 50 years have been the basis of a radically different account of the relation of perceptual to associative events. It reverses completely the earlier emphasis, proposing to replace an associative theory of perception with a perceptual theory of associations. This is the intent of the theory formulated by Köhler (1929, 1941). That percepts are organized signifies that the parts are in interaction, or that they mutually alter each other. Now the material of recall preserves, often quite correctly, the organization of earlier experience. It follows that memory traces, or the physiological bases of memory, are the aftereffects of preceding organization. This is to say that the terms associated no longer retain their independence; they are parts of a unified organization. In this formulation, an association is the persistence of a preceding organization, not an event added to the terms brought into association; in short, an association is fundamentally different from a mere connection between terms that remain independent. It also follows that conditions favoring organization in experience favor trace organization, and therefore recall.[19]

The results of this investigation provide, we propose, the most direct evidence for the relation of perceptual organization to coherence in memory. In this sense they furnish confirmation for the theory of Köhler. At the same time, neither of the principal theories of association has dealt directly with the problem of this study, namely, with the distinction between coherence within a unit and the coherence of one unit with another. It remains to be seen what the relation of the present problem and findings is to these positions.

A Further Distinction between Unitary and Nonunitary Coherence?

We have hitherto concentrated on the quantitative differences in memory between two kinds of stimulus conditions. We will now explore the thought that the difference in question is not adequately described in quantitative terms alone, that the two conditions are separated in a more systematic and far-reaching way. Finally, we will consider whether one process of coherence will suffice to account for both sets of data.

The problem can best be introduced by referring to a known fact concerning associative recall, but one that deserves to be

[19] The theory of Köhler concerns the effects of organization generally, and is not restricted to perceptual organization. The general formulations are, of course, intended to include perceptual organization.

better-known. The recall of an association, more particularly the recall of *b* when *a* is given, may fail for two fundamentally different reasons. 1. Recall will fail, at the time of test, if there is failure to recognize the given term *a*. This assertion follows from an assumption we consider compelling, namely, that associative recall presupposes a prior step of recognition (Köhler, 1940). 2. Recall of an association may not occur although the starting term *a* is recognized; in that case there is a failure in the recall *of an association.*

We now propose to examine the thesis that failure to complete a unitary stimulus has its source exclusively in the first of the two alternatives described above, but failure to complete a nonunitary pair, which often occurs despite recognition of the first member, is due to failure of associative recall. This may be restated positively as follows. When part of a unitary stimulus is recognized, the missing part will be invariably completed; in contrast, one of the members of a nonunitary pair may be recognized without producing completion of the other member. This distinction, if empirically established, might be a criterion of important differences in the underlying processes.

Before proceeding, let us note the conditions that have to be met in order to decide whether failure of recall is due to failure of recognition or of the recall of an association. First, it must be established that the association in question was formed. Second, it is necessary to determine whether recognition of the terms occurs at the time of test. Despite the obviousness of these requirements, there is very little concrete knowledge at present of the contribution of these factors. The investigation of memory has almost totally overlooked the distinction between these sources of failure of recall, a consequence of the neglect of the fundamental difference in process between recognition and recall.

One consequence follows from the stated hypothesis for the data of this investigation. Recall of a unitary stimulus should be *complete*; that is, recall of form and mode should not occur one without the other. (Implicit is the requirement that failure to recall a unitary stimulus should also be complete.) Since the present investigation was not initially designed as a test of the hypothesis, the following re-examination of the data will be somewhat indirect and only suggestive.

1. One source of evidence comes from a re-examination of the matching data of Experiment 8.

Experiment 8 included, in addition to matching, a test of recognition of form. We now selected those forms in the unitary series that were correctly recognized, and computed for each *S* the proportion of cases in which these forms were also correctly matched. The mean of these proportions was 63.8; that is, on the average 64% of recognized forms were correctly matched. It may seem that this result is negative for the hypothesis in question, but this would be an incorrect inference. As we have seen, the criterion put forward requires that the unitary stimulus should have been adequately perceived at the time of learning. If, for example, the *S* initially perceived the form but for some reason neglected the mode, subsequent partial recall would have no bearing on the hypothesis. We lack, however, direct information concerning the perception of modes in this condition. Fortunately, we can obtain an approximation to such a measure from Experiment 6, in which the conditions of learning were identical with those of Experiment 8, but the test was one of recognition of the forms and modes, respectively. The results appear in Table 18.

Proceeding as before, we selected all instances in Experiment 6 of correct recogni-

TABLE 18

RELATION OF RECOGNITION OF FORM TO PAIRING (in %)

	Experiment 6: "Synthetic Pairing"	Experiment 8: Matching: Intentional	Experiment 9: Matching: Incidental
Unitary	70.4	63.8	45.1
Nonunitary	84.0	31.6	19.2

tion of form in the unitary series and computed for each S the proportion of instances in which the paired modes were also recognized. The resulting values give us a measure of "synthetic pairing" of recognized forms. The significance of this measure is that it states the limit of actual pairings that can occur under the given experimental conditions. Actual pairing cannot exceed the level of synthetic pairing, which is an index of the joint *perceptibility* of forms and modes that belong to the same stimulus; the former can only be of lower frequency than the latter.

The mean proportion of synthetic pairings in Experiment 6 was 70.4; that is to say, on the average 70% of the recognized forms were accompanied by the recognition of their modes. The difference between this value and 63.8%, the value obtained in Experiment 8, is small and not significant ($p > .10$).

The preceding analysis assumes that the recognition data of Experiments 8 and 6 can be compared despite the differences of conditions at the time of test. (In Experiment 6 new items were interspersed with the old for the test of recognition; not so in Experiment 8. Further, the recognition test of Experiment 8 followed a test of matching.) Despite these differences, the levels of recognition of form were remarkably similar in the two experiments. Therefore, the comparison seems justified as well as the assumption that the two variations produced similar levels of recognition of modes.

When one takes into account the perceptibility of the stimuli in Experiment 8, the completeness of retention of the unitary stimulus is in accordance with the criterion. Nevertheless, a more direct test will be necessary for a definitive conclusion.

2. The data of Experiment 10 are also pertinent. Here we employed a procedure of familiarization preceding the main task, which insured the full identifiability of the stimuli at the time of learning. We also tested for recognition of the original stimulus series. For the purpose of testing the present hypothesis, this procedure may be the most sensitive. Our concern is to establish whether a given unit has been retained as a unit; given this aim, it is desirable that the test reduce the burden of recall proper to a minimum.

The interpretation of the results has to take into account the following detail: the test of recognition was itself a source of interference. We found that the position of the stimuli in the test series affected accuracy of recognition. Accordingly, we examined the level of recognition of stimuli that came *first* in the test series (these stimuli all appeared toward the middle of the learning series, in the fourth position, a position susceptible to interference). The level of accurate recognition of the unitary stimuli was 96% (in contrast to the level of 52% for the nonunitary stimuli). This result is based on one half of the stimuli in the unitary series.

The pertinence of this result derives from the following consideration. The procedure of familiarization made certain that there would be complete recognition of the parts of the unitary stimulus. Under these conditions we find that recognition of the belongingness of the parts is at a maximum, which is in accordance with the hypothesis.

3. Turning to the data of free recall, the hypothesis requires completeness of recall of the unitary stimulus. We have found that such inseparability was by no means always the case: isolated recalls and incorrect pairings did occur with measurable frequency. Before drawing a negative conclusion, the following points need to be considered. (*a*) The criterion in question presupposes, as we saw, that the stimulus was adequately perceived at the time of direct experience. We know that this was not the case throughout, if we may judge by the recognition data (see Experiment 6). (*b*) Further, it was quite possible to register a stimulus simultaneously in a unitary manner and discretely. The modes in particular were often highly familiar; the Ss were capable of perceiving them as parts of the stimulus and at the same time of recording them separately. Such multiple registration could also account for isolated recall. (*c*)

Finally, uncontrolled guessing could account for certain incorrect pairings. It should be noted in this connection that incorrect pairings occurred infrequently (see especially Experiments 1, 4, and 5 which are most pertinent). The free recall data are thus inconclusive. Failure of recognition, separate registration, and guessing limit their value for the present purpose.

Although the results of the preceding analysis are not definitive, they offer some support for the hypothesis when the necessary conditions are most adequately met. But further investigation, directly oriented to the hypothesis, is clearly needed. Such investigation will require the simultaneous determination of data not ordinarily obtained in experimentation: it will be necessary to establish that learning had occurred, and to relate, at the time of test, the data of recall to those of recognition.

Before concluding, the following remark may be in order concerning the criterion of invariable completion. It would be going too far to assert that the trace of a unitary percept cannot be disrupted under any conditions, that it must always persist—or disappear—as a unit. Our intention is to make a less sweeping assertion, to suggest that a unitary trace will persist as a unit under "normal" conditions, as long as no extreme measures are taken to disturb it. Admittedly, what is to be regarded as normal is left undefined at this point. Despite this shortcoming, and despite the uncertainties surrounding the hypothesis, the criterion directs us toward a valid problem. It asks us to consider what parts, or aspects, of a stimulus distribution are inseparable, or—since the criterion is a severe one—nearly inseparable. It can hardly be said, in the light of present knowledge, that investigation will fail to discover instances that meet the criterion.

Associative and Nonassociative Processes

The evidence for two substantially different kinds of stimulus conditions and effects prompts us to ask whether the respective operations are similar or distinct. Generally, in psychology, we take the joint recall of "two" data as evidence of association. Is it equally clear that the coherence of terms belonging to the same unit is an instance of association? There is the possibility that one uniform process is responsible generally for functional coherence, whether it occurs within a perceptual unit or between units. If so, it would follow that the conditions we have called unitary provided superior conditions *for association*. But we need consider also the alternative that there are distinct kinds of coherence, and that these are a function of the particular unit relations.

This question has not attracted attention mainly because the study of units has been the province of perceptual investigation, while associative studies have limited themselves to the combination of units. It has become evident, though, in the light of this investigation, that the properties of units are pertinent to the general problems of association. Further contributing to the prevailing assumption are the procedures currently employed in investigation, which are best designed to reveal quantitative differences between effects, thus creating the presumption of a uniform process. To speak of association is harmless as long as the term refers to a uniform set of procedures and effects. But as soon as it refers to different conditions and effects, it becomes charged with theoretical implications, and ceases to be merely descriptive. Surely, it would not be right to conclude that the unitary condition is associative simply because the procedure employed in studying it was that of the association experiment.

What grounds may there be for the hypothesis of a nonassociative kind of coherence? We would first mention an observation that is only suggestive. The typical associative situation (as represented in the nonunitary condition) begins with the apprehension of unrelated data that are *subsequently* joined; perhaps it is this transition from an initial to a later state that characterizes the step of association. The situation is importantly different when the data are *from the start* apprehended as members of

one unit. In the latter case the relation between the terms evolves directly as a perceptual process, lacking the transition from an initial to a terminal state. We are mindful that this observation is not conclusive; the difference in question could well be functionally continuous.

The following consideration seems to us the most compelling: the unitary condition produced an effect that no other pairing condition achieves. We know of two substantially different association experiments: that which pairs heterogeneous unit terms, and the pairing of units that stand in clear relations of fitting, of which the investigation of Prentice and Asch (1958) is an example. The unitary condition differs from the former of these in ways already described. It is now necessary to call attention to the critical difference between the unitary condition and that produced by related units. In the latter case coherence was also at a high level, but it was a consequence of intrinsic perceptual relations. The unitary condition produced comparable effects when the terms in question were heterogeneous. We know of no stimulus relation other than that internal to a unit that brings about this effect.

We need now consider whether these effects can be referred to a single process, since such a solution would introduce a most desirable orderliness in our thinking. In doing so let us refer to the three conditions of coherence that have been identified: (*a*) the pairing of distinct and heterogeneous units, as in the classical association experiment; (*b*) the pairing of units related by properties such as symmetry, completion, etc. (Prentice & Asch, 1958); and (*c*) the "pairing" of heterogeneous constituents of units. The three cases differ in fundamental respects: (*a*) and (*c*) are alike in heterogeneity but not in coherence; (*b*) and (*c*) are comparable in coherence but not in heterogeneity; while (*a*) and (*b*) differ in both respects. To assert that they are functionally continuous, we believe, requires the following arguments.

One would have first to reverse an earlier assumption and maintain that all of the preceding conditions are unitary, and that they differ solely in degree of unity. More particularly, this interpretation asserts that any pairing, however heterogeneous the terms, forms a unit; that coherence is a function of degree of unity or interdependence among the members of a stimulus distribution; and that the empirical discontinuities are a consequence of an underlying functional continuity. This is the position that Köhler (1929) has taken in a classic discussion, in which he speaks of association as "coherence within the unitary trace of an equally unitary or organized experience. . . ." (p. 282).[20]

To refer all functional coherence to organizational conditions, we believe, is to go in a necessary direction. The formation of the most recalcitrant association is evidence of interaction between the terms in question, and to this extent might also properly be called an instance of unit formation. We are not convinced, however, that this formulation, which was directed to the typical association experiments, fully takes into account the problem which the present investigation poses. The latter requires us to ask whether a unitary relation that is formed spontaneously is functionally identical with the unity established between heterogeneous terms. It is well-known that the properties and effects of interaction can differ considerably; indeed, interaction may also result in segregation. (To judge by the phenomenal evidence, this describes one aspect of the figure–ground relation of Experiment 11.) Thus, the issue is substantially unchanged when one takes into account the organizational character of rote associations.

The following would be a more direct way of deciding between the alternatives. If the stimulus conditions we have contrasted are functionally continuous, this could be demonstrated by finding intermediate stimulus distributions and observing whether

[20] At another point Köhler (1941) has again asserted that "the fact that a unitary process forms a unitary trace is equivalent to what we call an association. From the present point of view association is therefore simply coherence within the unitary trace of a unitary experience" (p. 493).

the results of coherence are correspondingly intermediate. Such investigation would be timely. We see the possibility of systematically varying for this purpose the degree of fittingness (and of other relations) between paired units. At this time, though, we know of no way to bridge the unitary relation we have here studied with the corresponding dual relation.

If there are distinct kinds of coherence, the resulting memorial processes must be correspondingly different. We will now attempt to derive this difference from the distinction, examined in the preceding section, between recall that invariably follows recognition and recall that may fail despite recognition. For the purpose of discussion we will assume what is still to be proven, namely, that there are specifiable stimulus conditions in which recall follows invariably upon recognition.

The particular statements to be examined are as follows.

1. Completion in memory that invariably follows recognition is an instance, not of recall, as is generally assumed, but of recognition. But completion in memory that may or may not follow upon recognition requires a distinct step of recall.

2. The first kind of completion is nonassociative, the second is an instance of associative recall. This formulation states an independent, although still quite indirect, property of an association: the criterion of an association is that recall of it can fail following upon recognition of the preceding term with which it was paired. This point deserves notice in the light of the observation that the occurrence of an association has hitherto not been defined except in terms of the employment of a particular experimental procedure.

3. It follows that completion in memory of part of a unitary stimulus is an instance of recognition, which is nonassociative, but completion between heterogeneous units is a case of associative recall.

For illustration we compare the following memory results:

1*a*. Recognition of a unit lacking natural subparts.

1*b*. Completion of part of a unit lacking articulated subparts.

2. Completion of a unit with articulated subparts.

3. Completion of heterogeneous unit pairs.

1*a*. An observer inspects a black elliptical contour line on a white ground. At the time of test the same figure appears with a number of others; let us suppose that it is recognized. The occurrence of recognition we interpret in accordance with Köhler's (1940) account of the Höffding function. The perception of the ellipse produces as an aftereffect a trace corresponding in organization to that of the percept. On its later appearance, the elliptical stimulus produces a new percept corresponding to current stimulation. The occurrence of recognition signifies that the latter process makes contact with the trace of the earlier percept, and that the contact is made possible by the similarity between them.

1*b*. The stimulus is as above—an elliptical contour line. At the time of test the observer is shown a portion of the ellipse, with instructions to reproduce the earlier stimulus. For completion to occur, the part-stimulus must be recognized as similar to the one that was seen earlier. That is to say, the present perceptual process, on the basis of similarity, must arouse the trace of the earlier percept. This situation differs in an obvious respect from the one just described earlier. The stimulus is now reduced at the point of test; the trace is contacted by a process that corresponds to it only partially. But the trace is of a unitary form *without* parts; the ellipse possesses a whole-quality that is given directly as a perceptual datum. (A sophisticated observer may of course apprehend the shape in a more analytical way, but we will assume that this is not the rule in immediate perception.) If, as in this case, the trace of the earlier organization is highly unified, it may not be possible to reactivate it without doing so in its entirety. Once trace contact of the kind described has occurred, the entire trace of the old stimulus will be activated, a direct consequence of its unity.

If so, the completion of the present example, or the *production* of a missing datum, does not differ essentially from the usual case of recognition, the distinguishing feature of which is that the test stimulus is not discriminably different from the learning stimulus. Thus, the criterion stated earlier would apply to the present case. We would have to predict that completion of the part-stimulus will invariably go with recognition, and failure of completion equally invariably with failure to recognize the part-stimulus. Accordingly, we may call the performance of example 1*a* an instance of "simple" recognition, and that of the present example an instance of "extended" recognition.

2. We will now consider the case of a unit with clearly articulated or natural parts. Figure 9 may serve as an example. It consists of a pair of lines differing in length. Let us present, at the time of test, the shorter of the pair of lines, and let us suppose that it is appropriately completed. This is an instance of *part–whole completion,* which may be of essentially the same kind as that discussed under 1*a* and 1*b*. If so, completion goes not from part to part—from *a* to *b*—but from part to whole, or from *a* to *ab,* where *ab* stands for the unit.

The unitary condition of this investigation has a structure not describable in terms of part–whole relations (see p. 33), but the same analysis would apply if it were empirically established that recall of form and mode are invariably joint.

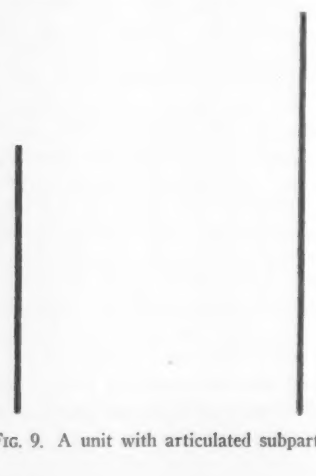

FIG. 9. A unit with articulated subparts.

3. For the third condition we select a pair of heterogeneous stimuli; let these be the ellipse and the line pair of the preceding examples. Let the test stimulus again be a portion of the ellipse, and let us suppose that it is properly completed. Now the *S* may proceed to recall the second term, the line pair—or he may fail. On intuitive grounds and on the basis of available evidence, the two kinds of completion are not equally probable. It would indeed be surprising to find that the completion of the first unit of this example failed at the same time that recall of the second unit succeeded.

Our procedure is entirely psychological, and we have not attempted to characterize the neurophysiological processes. We may assume that memorial completion, whether recognitive or associative, involves a spread of excitation in the affected memory traces. The question then becomes one of specifying a difference between these respective excitations. The answer that this discussion has foreshadowed is that excitation spreads evenly through a unitary trace, but must overcome a further barrier when it goes from the trace of one unit to another. Or, no part of a unitary trace can be activated without arousing the entire trace, while the spread of excitation from the trace of one unit to that of another is analogous to jumping a gap, and must overcome greater resistance.

Before concluding, we may note the relation of what has been said to the main issues in this region. Evidence for distinct kinds of coherence would require an important revision of thinking about associative, and, by the same token, perceptual phenomena. It would establish the reality of perceptual conditions of association and of a nonassociative kind of perception. One consequence would be to remove a considerable range of functional coherence from the scope of association, contrary to what has been generally assumed, and to restrict associative phenomena to a narrow, perhaps a special, category. More particularly, it

would follow that stimulus relations of a strongly unitary kind are perceived and recalled nonassociatively, and that an associative process arises only when the perceptual nexus between the parts of stimulus distribution is reduced.

We may also note the consequences for the main theories of association. These have not specifically considered the problem here at issue; basing themselves upon a more restricted body of evidence, each has adopted a single conception of coherence. It is instructive to observe that the question of kinds of coherence raises quite different problems for these theories. Associationistic accounts might simply shelve the new problem and consider that a strictly perceptual coherence falls outside the scope of their concern. This way is not open to a gestalt theory, precisely because it derives associative phenomena from the facts of organization. It is, therefore, with the relation of the latter position to the present account that we were most concerned.

The problem, which we leave at this point, has been stated but not resolved. The difficulties in seeking a solution arise from our inability to characterize association independently as a process; this was, in part, the aim of the preceding discussion. Given our limited understanding, one can at present adopt either alternative with a fair appearance of consistency. It remains for further investigation to decide between them.

This investigation opens up issues that extend beyond the limits of experimentation here reported. They grow out of the consideration that the coherence and recall of units is as fundamental as the coherence between one unit and another. Not to study the former in its own right, and in relation to the latter, is to neglect a considerable range of phenomena. When one takes this formulation into account, new problems can be discerned, of which the following are a few examples.

1. One can abstract from the theoretical matters discussed above to ask a concrete empirical question: What stimulus distributions are related "indissolubly," or are invariably recalled jointly once they are perceived, and what stimulus distributions are separable in recall? It would be of consequence to identify stimulus relations that clearly have the one or the other property. The study of invariable coherence in the sphere of visual perception would help to establish what properties are *form-inherent*, or constitutive of the identity of the form. Investigation following this direction would be of equal relevance to a psychology of memory and perception. Indeed, we see here the possibility of clarifying questions concerning perceptual organization in the light of memory data.

2. A second question concerns the psychological constitution of *objects*. The formation of an object has long been regarded as the product of association between sense data, as literally made up of bundles of associated data—of a given shape, color, hardness. Since each sense datum had the property of a unit, the formation of an object was said to result from the association of units. This investigation brings forward an alternative way of thinking that may be deserving of investigation. An object is experienced as a unit; its properties or aspects are experienced as mutually dependent, in a manner that makes them parts of the unit. Let us restrict ourselves to the properties of objects that have their source in different modalities, such as vision and touch. If one takes seriously the phenomenon of unity, one is prompted to ask whether the coherence of data from different modalities is not furthered precisely because they are referred to the *same* object. The coherence of data from distinct modalities is a question fraught with theoretical interest and long neglected.

3. The role of unity has been here considered exclusively in relation to perception. Since organization is not limited to the perceptual sphere, the question arises whether the findings and interpretations of this investigation have a wider relevance, whether they apply to unit formation generally. We may illustrate by referring to the bearing of the investigation on the relation of *meaning* to association. A relation of meaning is a

well-known and strong condition of coherence. This effect of meaning has been variously interpreted. Often, it has been referred to familiarity produced by past experience. While this is often the case, one may doubt the adequacy of this interpretation in all cases. A relation of meaning is also an instance of conceptual unit formation; the advantage that meaning introduces is doubtless a consequence of this fact. The question one might raise is whether the contribution of meaning in the setting of the association experiment is at all unique, and whether the advantage it provides is not completely a function of the relation of unity it establishes.

Summary

The traditional study of associations is part of a more inclusive problem, one that concerns the relation between the objective structure of the stimulus and the coherence of its parts, as evident in perception and memory. The classical association experiment has restricted observation to a limited phase of this problem. It has concentrated on the coherence established between pairs of heterogeneous units. Theory and investigation in this area have not considered the formally analogous operations within well-structured units. This study was concerned with the effect of the perceptual relation of unity between the parts of a stimulus distribution on the capacity to retain them jointly.

Employing the technique of the classical association experiment, and visual forms as stimuli, the perceptual relations between the parts of a stimulus distribution were systematically varied. The following conditions were studied: the relation of constitution or composition, the relation of figure and ground, the relation of inclusion, and the relation of contiguity between pairs of heterogeneous units. The contents or terms composing the several relations were either identical or closely similar. The relations in question were phenomenally describable as either unitary or nonunitary.

Coherence of recall, or the ability to recall jointly the parts of a stimulus distribution, was substantially superior when the data belonged to the same perceptual unit. Errors in recalling "what went with what" were regularly more frequent when the parts of a stimulus distribution belonged to perceptually distinct units. These differences persisted with different tests of recall, and also when the test was that of recognition, thus establishing that the effect occurred at the point of direct experience.

The results demonstrate a direct relation between the unit properties of the stimulus and coherence. Given a difference of the unit relation between two stimulus distributions, the direction of difference between them in coherence of recall can be predicted.

The question was considered whether coherence within and between units may differ in process. The hypothesis was examined that the spread of excitation from one unitary trace to another requires a step not present in the spread of excitation within a trace. A test of the hypothesis was proposed, which rests on the differential role of recognition in the unitary and nonunitary instances. A re-examination of the empirical data offered a degree of support for the hypothesis, but a definitive conclusion awaits further investigation that meets strictly the experimental conditions required by the tests.

The consequences of the preceding hypothesis for a theory of associations were examined, as was also its relation to current theories of associations.

The relation of this study to a range of questions in general psychology was discussed.

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APPENDIX

SEPARABILITY OF FORM AND MODE

Units differ in degree of coherence. There is also reason to believe that units differ with respect to the range of conditions under which they will remain coherent. Indeed, resistance to disturbing conditions may be an index of degree of unity. The following experiments were an attempt to explore the unity of the form–mode relation by means of a new procedure.

In the preceding investigation the *Ss* were uniformly directed to note both the form and mode of each stimulus. We now undertook, by means of altered instructions, to see to what extent it is possible to direct the *S* exclusively to the form or mode alone of the unitary stimulus. The degree to which this separation can be achieved may serve as an index of lack of unity. In short, we take *separability* of the properties of a unitary stimulus as a criterion of unity.

Experiment 15: Separability of Form from Mode

The unitary stimuli of Experiment 5 were the materials of this experiment. The procedure was that of Experiment 5, except for the following modification. The *Ss* were instructed that the task was to recall only the *forms*. The instructions stated in part: "Your task is to recall the larger shape alone. You may be interested to know that we are comparing the recall of the larger forms under this condition with one in which the contour line is always drawn continuously (an illustrative card with the same form in continuous contour and with another modal contour was here shown). It just so happens that you have been assigned to the group with different contour lines. After I have shown you the cards once, I will ask you to draw as many of the forms as you can remember, using a continuous line, such as this (pointing to the illustrative continuous sample)." This explanation provided an effective rationale.

The test, which came after 3 min., was one of free recall. At this point, however, the *Ss* were instructed to reproduce, whenever possible, the modes as well as the forms as they were initially given.

The design of this experiment thus combines an intentional with an incidental procedure. It directs the *Ss* to focus on one aspect of the stimulus—the form—and to disregard the other; at the same time the perception of the one must carry with it the registration of the other. In this respect the technique is similar to that of the Külpe abstraction experiment.

Experiment 16: Separabiliy of Mode from Form

The stimuli and the procedure were identical with those above, except that the *Ss* were instructed to recall the *modes* only. Thus, this condition was incidental for the form, and intentional for the modes.

The results of both conditions appear in Table 19.

TABLE 19

RECALL SCORES

Experiments 15 and 16

	N		1 +(FM)	2 −(FM)	3 F	4 M	*M*
Experiment 15	12	*M*	3.2	1.2	3.8	0.1	8.3
		%	38.4	14.1	46.5	1.0	
Experiment 16	17						
a. Totally obedient *Ss*	5	*M*	2.8	1.2	0.2	5.2	9.4
		%	29.8	12.8	2.1	55.3	
b. Totally disobedient *Ss*	3	*M*	6.7	1.3	0.7	1.0	9.7
		%	68.9	13.8	6.9	10.3	
c. Intermediately obedient *Ss*	9	*M*	6.2	0.7	0.8	2.9	10.6
		%	60.2	6.5	5.4	27.9	

1. We will first examine the results of Experiment 15.

Perhaps the most noteworthy finding is that the *S*s were capable of complying with the instructions. Of a total of 14 *S*s, 12 were completely obedient to the instructions, judged by their answers to questions, at the conclusion of the experiment, concerning the procedure they adopted during learning.

The quantitative results, which appear in Table 19, provide convincing evidence of the effectiveness of the instructions. Most pertinent is the comparison of form and mode recall. The mean recall of forms was 6.0; of modes, 2.3. Each *S* recalled more forms than modes. Equally telling are the data for isolated recalls: of 47 isolated recalls, 46 were of forms.

As further evidence of the effect of this condition, we may cite the following. At the conclusion of the experiment the *S*s were shown the modes, each drawn as a straight line, and tested for recognition. (The decision to proceed in this way was made when the experiment was already in progress, and was applied to only 8 *S*s.) Although this was not an adequately controlled test of recognition, the results are instructive. The mean number of modes recognized was 5.3, a level considerably below that obtained in Experiment 6. Individual recognition scores ranged from 2 to 8.

In the light of these findings, it is not surprising that the level of joint recall was low. In absolute terms the level was one fourth of that in the U condition of Experiment 5, and less than one half of that in the non-U condition. Correct pairings were also depressed proportionately, when compared with the level of the non-U series of Experiment 5.

2. The majority of *S*s of Experiment 16 found it far more difficult to obey the instructions. They reported that the form remained dominant, and that they involuntarily referred to it when attempting to commit the modes to memory. Compliance with the instructions was again judged on the basis of the *S*s' replies to questions put at the conclusion of the experiment concerning their procedure during learning, and without knowledge of their recall performance. Out of a total of 17 *S*s, only 5 succeeded in obeying the instructions; 3 were completely disobedient; and 9 were judged to be intermediate.

In Table 19 we categorized the recall data in accordance with this classification. Despite the small numbers of cases, the results fall into a clear pattern.

a. Fully obedient *S*s performed in a manner that completely corresponds to the performance of nearly all *S*s in Experiment 15. There was a striking preponderance of mode over form recall, the respective means being 7.2 and 2.2. Out of 27 isolated recalls, 26 were recalls of mode. All 5 *S*s showed the same superiority of form over mode recall.

Correct pairings were markedly depressed; there were only 7 such instances. Even this figure is inflated, since all cases of joint recall were of the first two stimuli in the learning series, that is, of those appearing during the phase of least crowding.

Thus, separability of form and mode was achieved in this, as in the preceding experiment, although by fewer *S*s.

b. The three totally disobedient *S*s differed strikingly from the preceding group. Recall of forms and modes was now identical. Most noteworthy was the drop of isolated recalls. In all respects these *S*s resembled closely the U *S*s of Experiment 5; this was so especially with respect to the frequencies of correct and incorrect pairings. Further, correct pairings were no longer confined to the early stimuli in the series.

c. The intermediate *S*s fell between the two preceding groups. There was a preponderance of mode recall; the latter accounted for the 61.3% of all recalls. Pairing was close to the U variation of Experiment 5.

We tested all *S*s for recognition of form. These were shown at the conclusion of the free recall test, drawn in continuous contour. The mean recognition score was 5.9, again considerably below the level obtained in Experiment 6. Individual recognition scores ranged between 2 and 10.

Complete separability was not achieved in either experiment. But a substantial degree of separability occurred under both sets of instructions.[21] Also, it was easier to focus on the form than on the mode, a result in accordance with earlier evidence that recall of form predominated in the unitary condition (see pp. 8, 11).

A full interpretation of these findings must await further investigation of the relative ease of separation of unitary stimuli of other kinds.[22] It would be of particular interest to identify those part-properties of stimuli that cannot be divorced from each other in perception and recall.

Under the conditions here described, one property of a stimulus was made focal and another peripheral; at the same time the perceptual situation was such that the ignored property could not but be registered. It was hardly possible to inspect the form without registering the modes as a visual datum, and conversely. That the ignored property

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[21] The procedure of testing for recall probably underestimates the actual level of coherence. This in no way weakens the weight of the comparison between the present data and those obtained under the fully intentional conditions of Experiment 5, which also employed the test of free recall.

[22] We have not done corresponding separability experiments with the nonunitary series. Such investigation might be appropriate as part of a systematic inquiry, but the results obtained earlier with the nonunitary series justify the surmise that such a procedure would probably be extremely effective.

suffered in recall, and even more important, in recognition, is evidence of the importance of attention, as distinct from sheer stimulation, in learning.

The following caution must be noted in interpreting the preceding results. Separation of form and mode was achieved only as a consequence of a special attitude induced by instructions to the *S*. It would be unwarranted, and probably misleading, to infer that form and mode were equally separable under the conditions of the main experiments of this investigation, and that this separability was counteracted by an equally special attitude in the opposed direction. It is more likely that we have here tested separability under extreme conditions, and that neutral conditions would demonstrate a considerable coherence of form and mode. These comments make clear the need for study of the coherence of the form-mode relation, as of other units, under "neutral" conditions, such as will avoid directing the *S* either to the entire stimulus distribution or to any aspect of it. Such a procedure should throw light on the modes of apprehension of stimulus relations under relatively spontaneous conditions.

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